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The effect of emotional reactions upon retention : with an appendix on A quantitative study of the similarity factor in retroactive inhibition

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THE EFFECT OF EMOTIONAL REACTIONS UPON RETENTION

With an appendix on

A QUANTITATIVE STUDY OF THE SIMILARITY FACTOR IN RETROACTIVE INHIBITION

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THE EFFECT OF EMOTIONAL REACTIONS UPON RETENTION

INTRODUCTION

The question involved in the present paper is but one phase of the general problem of retroactive inhibition. This concept originated with Müller and Pilzecker (19) who found in their extensive investigation of the phenomena of memory (1892-1900) that the interpolation of certain forms of activity between learning and recall seemed to interfere with the reproduction of the original material, i.e., that it seemed to accelerate the forgetting process. Since their work a number of studies have been made dealing with different phases of the problem. Factors determining or influencing the degree to which the interpolated material interferes with the recall, relearning, or recognition of the original material have furnished the problems for the majority of these investigations. The factors so studied include (1) the similarity of original and interpolated activities, (2) the effect of the temporal position of interpolation, (3) the degree of learning, (4) the effect of practice, (5) the conditions of

learning, (6) the length of the series, (7) the rôle of individual differences, (8) the effect of difficulty of interpolation, (9) the relative susceptibility of rats and human subjects to retroactive inhibition, and (10) forward reference vs. retroactive effects.

The purpose of this paper is to review the literature, to give the present status of each of the problems enumerated above, and to present an experimental study on a further problem, i.e., the effect of emotional reactions, as the interpolated activity, upon retention.

Skaggs (25) has suggested that this factor be designated as emotional retroaction, thus allowing a stricter definition of the general concept of retroactive inhibition. However, since the term retroactive may be rather misleading as a descriptive term, the writer prefers to use the more accurate term of emotional interference. This term has no necessary implication of a backward reference, but rather refers definitely to the experimental conditions in which retention is tested after an emotional disturbance.

HISTORICAL REVIEW

Studies of Retroactive Inhibition with Human Subjects.

Müller and Pilzecker (19).

Müller and Pilzecker devoted a section of their monograph to the description of a series of experiments which were designed to show that the introduction of mental work immediately succeeding the learning of a list of nonsense syllables interfered with the later memory for that list.

Their apparatus consisted in a 12-sided prism which revolved behind a metal screen in which was an adjustable slit. A strip of paper on which were written 12 syllables was placed around the revolving prism. The Hipp chronoscope and a lip key were used to record the reaction time for recall. Both the right associates and the savings methods were used. In the case of the five experiments with the former method the results were secured from tests with two sets of lists. These tests differed only in the manner in which the interval between learning and recall was used. For the one test the subject was left entirely free for this interval,

while in the interval in the other test he engaged in some form of mental activity, "work," such as learning another list or studying pictures for an Aussage test.

The original data are presented by Müller and Pilzecker in a series of short summaries. Tolman (26) has gone over all these data and in his excellent historical summary has presented the exact conditions and results of these early experiments. The following tables are revised slightly from those found in his paper. Here "Exp." represents the number of the experiment as given by the authors, "n" refers to the number of syllable pairs used in each test; "R" indicates that part of the experiment in which the rest interval was used; and "W", that in which the work interval was used. The column headed "RL" presents the number of repetitions given for the original learning; "%R" shows the percentage of correct responses made on the test, and the "Time" column gives the reaction time of response. Only one subject was used in each experiment. (These captions will be used in this manner throughout this paper where the right associates method was used in the original investigation. An attempt has been made to

present the essential conditions and results in a uniform manner in all the tables, hence the tables are not in the original form.)

Using both time and percentage of correct replies as criteria, there is evidence in these results as shown in Table 1 of greater inhibition for the lists followed immediately by work than for those followed immediately by rest. In Experiment 34 it will be noted that both intervals were used for work, but in the first test (W_1) the work followed six minutes after the learning, while in the second (W_2) it followed immediately (in 17.6 seconds) after the learning. The results of this experiment show that the loss is greater when work follows immediately after learning than when it follows after an interval of rest.

For the experiments in which the savings method was used Table 2 shows the experimental conditions and results. The last column (R. Rel.) in this case shows the average number of repetitions necessary for relearning. "n" stands for the number of lists used.

Table 1. Conditions and Results of Müller and Pilzecker's Experiments 31-34.

Exp.		n	Interpolated Interval	RL	%R	Time (Sigma)
31(a)	R	14	6 min. rest	8	48	2400
	W		34.4 sec. rest, study new series 68.8 sec.; 6 min. rest	6	23	3750
31(b)	R	72	24 hr. Rest followed by usual activities	16	36	3460
	W		24 hr. Rest 1 min.; study new series 2 min. 17.6 sec.; usual activities	16	32	3660
32	R	162	8 min. rest	12	55	3070
	W		17.8 sec. rest; study new series 1 min. 46.8 sec.; rest 8 min.	12	27	3230
33	R	72	8 min. rest	6	72	2090
	W		27 sec. rest; study new series 1 min. 12 sec.; rest 8 min.	6	43	2260
34	W_1	144	6 min. rest; study new series 1 min. 48 sec.; rest 10 min., followed by other activities	12	49	3000
	W_2		17.6 sec. rest; study new series 1 min. 48 sec.; rest 1o min.	12	28	2760
35	R	108	8 min. rest	8	56	2940
	W		2 min. Aussage test; 6 min. rest	8	24	2950

Table 2. Conditions and Results of Müller and Pilzecker's Experiments 36-37.

Exp.		n	Interpolated Interval	RL	R.Rel.
36(a)	R	8	4 min. rest; other lists; 10 min. rest (30 min. in all)	5	11.25
	W		Study new list; 4 min. rest; other lists and rest; 10 min. rest (30 min. in all)	5	13.00
36(b)	R	32	4 min. rest; other lists and rests; 5 min. rest	4	6.6
	W		1 min. 20 sec. study new list; other lists and rests; 5 min. rest (15 min. in all)	4	7.8
37	R		4 min. rest; other lists and rests; 5 min. rest	5	4.9
	W		Aussage test 2 min.; 4 min. rest; other lists and rest; 5 min. rest (15 min. in all)	5	8.0

Again the poorer records as measured by the number of trials necessary for relearning are made after the work intervals. From the results shown in Tables 1 and 2 a number of general conclusions were drawn. The more important of these are:

1. The results seem to indicate the presence of retroactive inhibition.

2. Under ordinary circumstances the effect

is weaker when the interpolated work is done after six minutes rest than when it is done immediately after the learning.

3. The results in the experiment where the Aussage test was used as the interpolated activity seem to indicate that similarity or dissimilarity of the original and interpolated activities is not an important factor in determining the degree of inhibition.

Heine (7).

The second major study of the problem of retroactive inhibition was carried on by Rosa Heine, a student of Müller, in 1910. Her problem was to determine whether or not retroactive inhibition played a part in recognition memory similar to that which Müller and Pilzecker had found in recall memory; she also wished to repeat the experiments of Müller and Pilzecker on recall memory and to discover new principles, if possible.

In a series of 19 experiments with recognition memory no evidence was found of inhibition. Fourteen experiments were then conducted on recall memory, with results very similar to those of Müller and Pilzecker.

Her methods were but slightly different from theirs: for the original learning series of 16 nonsense syllables instead of 12 were used; and in Experiments 15 and 16 eight four-place numbers were used. Table 3 summarizes the conditions and results for the first four of these experiments.

Table 3. Conditions and Results of Heine's Experiments 13-16.

Exp.		n	Interpolated Interval	RL	%R	Time (Sigma)
13	R	126	8 min. rest	8	17.5	2445
	W		2 min. Aussage test; rest 6 min.	8	6.4	3503
14	R	108	8 min. rest	10	57.4	1395
	W		2 min. Aussage test; rest 6 min.	10	36.1	1557
15	R	72	90 min.: rest 6 min.; other activities	12	36.1	2450
	W		90 min.: study new series 4 min.; other actitivies	12	9.7	2837
16	R		24 hr.: 6 min. rest; other activities	15	37.7	2123
	W		24 Hr.: 4 min. study new series; other activities	15	35.4	2987

Both the record of correct responses and the reaction times again give evidence of more inhibition for the work series.

Heine next turned her attention to the problem of discovering whether or not retroactive inhibition not only plays a part in association between successive syllables, but also in associations within the syllables. To test this she conducted a series of five experiments, using a procedure similar to that used before, except that the final test consisted in the presentation of two letters of each syllable, the subject being required to supply the third letter. The conditions and results of these experiments are shown in Table 4. The data seem to show that associations within the syllables, as well as the associations between the separate syllables, are weakened by the interpolated activities.

Five of Heine's 14 experiments on recall memory dealt with the problem of whether or not strongly impressed associations are relatively less affected by retroactive inhibition than weaker ones. In this group of experiments four lists were learned each hour.

Table 4. Conditions and Results of Heine's Experiments 17-21.

Exp.		n	Interpolated Interval	RL	%R	Time (Sigma)
17	R	216	9 min. rest	8	48.6	2799
	W		3 min. study list of 8 4-place numbers; 6 min. rest	8	35.2	3443
18	R	216	9 min. rest	12	37.5	1993
	W		3 min. study list of 8 4-place numbers; 6 min. rest	12	27.6	2940
19	R	216	9 min. rest	8	73.6	1707
	W		3 min. study list of 8 4-place numbers; 6 min. rest	8	56.9	1993
20	R	144	9 min. rest	10	32.7	3935
	W		3 min. study list of 8 4-place numbers; 6 min. rest	10	15.9	5601
21	R	216	9 min. rest	12	47.7	3784
	W		3 min. study list of 8 4-place numbers; 6 min. rest	12	38.0	4237

These lists were designated R, W, r, and w. The R and W lists differed from the r and w lists only in that they were given a greater number of repetitions and were recalled after a greater interval of time. The conditions and results of the three of these experiments in which the right associates method was used are shown

in Table 5. Two experiments in which the savings method was used gave results as shown in Table 6.

Table 5. Conditions and Results of Heine's Experiments 29, 32 and 33.

Exp.		n	Interpolated Interval	RL	R%	Time (Sigma)
29	R	108	24 hr.: 10 min. rest	30-20	62.0	2406
	W		3 min. study new series; 6-7 min. rest	30-20	36.2	3013
	r		9 min. rest	6-2	70.4	1939
	w		3 min. study new series; 6 min. rest	6-2	21.1	2683
32	R	144	30 min. rest	25	22.2	5055
	W		3 min. study pictures; rest	25	20.2	5161
	r		8 min. rest	8	17.5	2445
	w		s min. study pictures; rest	8	6.4	3505
33	R	108	24 hr. rest	25	11.1	2030
	W		3 min. study pictures; rest	25	16.7	1946
	r	108	8 min. rest	10	57.4	1395
	w		2 min. study pictures; rest	10	36.1	1557

The results obtained by the use of both methods indicate greater inhibition for the more weakly impressed lists. The findings of all of Heine's

Table 6. Conditions and Results of Heine's Experiments 30-31.

Exp.		n	Interpolated Interval	RL	R.Rel.
30	R	24	90 min.: rest and other activities	8	25.2
	W		90 min.: 3 min. study new list; rest and other activities	8	25.2
	r		90 min.: rest and other activities	4	21.2
	w		90 min.: 3 min. study new list; rest and other activities	4	22.2
31	R		90 min.: rest and other activities	12	24.2
	W		90 min.: 3 min. study new list; rest and other activities.	12	25.3
	r		90 min.: rest and other activities	6	20.3
	w		90 min.: 3 min. study new list; rest and other activities	6	22.5

experiments may be summarized briefly as follows:

1. In the 19 experiments dealing with recognition memory there is no evidence of retroactive inhibition.

2. In the four experiments dealing with the problem of recall memory the findings of Müller and Pilzecker are substantiated.

3. The five experiments dealing with associations within the syllables show an effect of inhibition similar to that shown to exist between successive syllables.

4. The concluding five experiments on the effect of the degree of impression indicate a lesser degree of inhibition for the more strongly impressed associations.

DeCamp (4).

DeCamp started to work on the problem of retroactive inhibition before Heine's work had been reported in full. (Müller made a brief report of her work before the Fifth International Congress of Experimental Psychologists in 1912.) He began work on the assumption that the principle of retroactive inhibition had been definitely established; but he obtained results which contradicted the findings of Müller and Pilzecker and Heine.

DeCamp was primarily concerned with the determination of relative degrees of inhibition produced by various amounts and different distributions of work. Seven trained subjects were used in Experiments 1 to 12, while 34 untrained subjects served in Experiment 13. The right associates method was used except in the last experiment where the reconstruction method was employed. The subject was shown a series of seven pairs of nonsense syllables, the two members of each pair being exposed simultaneously. These were presented on a Wirth card exposure apparatus, timed with a metronome. In the case of the reconstruction test the subject studied an arrangement of five men on a chess board for 15 seconds, and after a period of rest or work was required to reconstruct the arrangement. Errors in position and time were the measure of efficiency of recall in this experiment. Correct responses and time were recorded in the other experiments. The interpolated period in all cases of the work interval was spent in mental multiplication, ergograph work, problem solving, or chess playing. Seven of the experiments resemble those of Müller and

Pilzecker rather closely in method, although the results do not indicate so clearly the influence of inhibition as do theirs. Table 7 summarizes these seven experiments. In Experiments 3, 5, 6, and 8 both correct reponses and time values indicate inhibition, but not so clearly as do those of the former investigators. In the other experiments the results are either negative or doubtful.

In another group of four experiments a large number of different distributions of rest and work were examined. In two of the experiments the interpolated period was 15 minutes in length, arranged in this manner: Rest 15, Work 0; Rest 14, Work 1; Rest 13, Work 2, etc., until the condition had become Rest 0, Work 15. In the other two experiments the last nine minutes were given over to rest in each case, while the activity of the first six minutes was varied.

The results did not indicate that the distribution of work through the 15 minute period was an important factor. Direct evidence for or against the general principle of retroactive inhibition may be studied by comparing the two extreme distributions, Rest 15-Work 0, and Work 15-Rest 0 in the first two experiments.

Table 7. Conditions and Results of DeCamp's Experiments 3, 5-9, and 11.

Exp.		n	Interpolated Interval	RL	%R	Time (Sigma)
3	R	112	15 min. rest	10	48	2221
	W		10 min. multiplication; 5 min. rest	10	33	2676
5	R	70	15 min. rest	10	34	5149
	W		15 min. multiplication	10	30	5822
6	R	63	15 min. rest	10	79	2828
	W		10 min. multiplication; 5 min. rest	10	68	2955
7	R	70	15 min. rest	6	41	5127
	W		10 min. multiplication; 5 min. rest	6	40	4286
8	R	63	15 min. rest	10	67	4862
	W		1 min. adjusting ergograph; 10 min. work; 5 min. rest	10	43	4108
9	R	56	15 min. rest	10	53.6	5238
	W		6 min. solving problems; 9 min. rest	10	46.4	5593
11	R	70	15 min. rest	8	40	2343
	W		10 min. chess; 5 min rest	8	50	2392

Table 8 shows this comparison. It also presents the results of Experiments 9 and 10.

Table 8. Conditions and Results of DeCamp's Experiments 1, 2, 9, and 10.

Exp.		n	Interpolated Interval	RL	%R	Time (Sigma)
1	R	28	Rest 15 min.	16	18	2250
	W		15 min. work arithemetic	16	18	4250
2	R	51	15 min. rest	16	50	6700
	W		15 min. work arithmetic	16	55	6850
9	R	140	15 min. rest	10	41	6349
	W		6 min. work arithmetic; 9 min. rest	10	31	4669
10	R	42	15 min. rest	10	33	2500
	W		6 min. work arithmetic; 9 min. rest	10	36	2149

A slight indication of the influence of retroactive inhibition is found in the %R record in Experiment 9 and in the time records of Experiments 1 and 2, but the results are not nearly so conclusive as those found in the former studies.

Experiment 4 was designed to test two distri-

butions: Rest 6, Work 9, and Rest 2, Work 13. Experiment 12 was the only test where a number of individuals was used. Experiment 13 was made with the reconstruction method. Records of errors in position and of time were kept in this experiment. The results of Experiments 4, 12, and 13 are given in Table 9. The data obtained in Experiment 4 indicate a greater loss for the Rest 2-Work 13 condition. The results of the other two experiments indicate practically no loss.

Table 9. Conditions and Results of DeCamp's Experiments 4, 12, and 13.

Exp.	n	Interpolated Interval	RL	%R	Time (Sigma)
2 W_1	70	6 min. rest; 9 min. work	10	29	2675
W_2		2 min. rest; 13 min. work	10	37	3328
12 R	14	15 min. rest	12	42.5	2047
W		6 min. solving problems; 9 min. rest	12	42.0	2184
			Errors		
13 R	36	3 min. rest	10.4		67.4 sec.
W		2 min. arithmetic; 1 min. rest	11.7		66.2

DeCamp suggests the following conclusions "as

indicated, if not wholly proven:

"1. That retroactive inhibition plays a significant part in influencing the recall of nonsense syllables, either from the standpoint of the number of successes, or the length of the reaction time, or both, appears exceedingly doubtful.

"2. No positive introspective evidence appeared in favor of retroactive inhibition.

"3. With inexperienced subjects no evidence appeared in favor of retroactive inhibition, either from a combination of their results, or from a consideration of their comparative results.....

"6. The B series of syllables possessed a slight disadvantage as compared with the A series, probably due to a slight fatigue effect occasioned by the A series. (A list--R list; B list--W list.)

"7. Different subjects showed no marked individual differences with respect to the manifestation of the effect of retroactive inhibition." (p. 68).

Tolman (26).

Before DeCamp's study was published, Tolman,

also working upon the assumption that the principle of retroactive inhibition had been definitely established, began the study of a special phase of the problem, i.e., the effect of the conditions of learning upon the degree of retroaction. The conditions studies were (1) pleasant vs. indifferent learning material; (2) normal vs. distracted attention; (3) with caffeine vs. without caffeine; and (4) efficient vs. inefficient working periods. In each pair of conditions Tolman describes one as "more stimulating," and the other as "less stimulating."

Four experiments were carried out to determine the effect of the kind of learning material used. The materials learned consisted of lists of words or lists of words and numbers judged pleasant or unpleasand by the experimenter, or by himself and a few observers. These lists were presented either on a revolving kymograph drum or on the Rupp-Lipmann apparatus. Time was taken by a lip-key and stop watch connected with an electric magnet. The right associates method was used. The results are presented in Table 10.

Table 10. Conditions and Results of Tolman's Experiments 1-4.

Exp.		n	Interpolated Interval	Pleasant RL	Pleasant %R	Indifferent RL	Indifferent %R
1	R	40	9 min. rest	2.5	60	3.1	80
	W		3 min. study checker-board of consonants		40		30
2	R	48	9 min. rest	8.9	52.1	9.8	60
	W		3 min. study checker-board of consonants		64.6		47.9
3	R	40	9 min. rest	8.9	52.5	10.9	52.5
	W		3 min. study checker-board of consonants		57.5		42.5
4	R	40	6 min. rest	7.6	42.5	8.6	46.3
	W		3 min. study checker-board of consonants		55.0		47.5

It will be noted that the number of repetitions for the learning of the pleasant and indifferent lists varies in these four experiments. The reason for this was as follows: "..... if we are to prove conclusively that the L (less stimulating) condition is really more affected by retroactive inhibition than the M (more stimulating) condition, we must regulate our results (by extra repetitions, if necessary, in

the case of the L condition), so that r (percentage of successes) for the p lists is equal to or greater than that for the P lists. Only then will a greater difference of (r for p lists)-(r for w lists) than (r for P lists)-(r for W lists) indicate conclusively that the L condition was more affected by work." (p. 19). (p is used to designate the indifferent lists which were followed by rest; P indicates the pleasant lists followed by work; w represents the indifferent lists followed by work, and W represents the pleasant lists followed by work.)

Insofar as the results of Experiments 2, 3, and 4 indicate no inhibition or even facilitation for the pleasant lists, and but slight inhibition for the indifferent lists, the negative findings of DeCamp are supported. However insofar as, when combined with Experiment 1, they present a uniform tendency for retroactive inhibition to appear more readily in the indifferent lists, they point to a possibility that in the case of two contrasted conditions of learning, one condition may be consistently more affected by retroactive inhibition than the other. The succeeding

experiments were undertaken to test out this possibility.

The second group of experiments dealt with normal vs. distracted attention. Distracted attention was produced by the tapping of a telegraph key on the revolving drum which the subject was required to duplicate by striking a pencil on the table as he studied the syllables. The following results were obtained:

Exp.	n	Interpolated Interval	Normal		Distracted	
			RL	%R	RL	%R
5 R	72	6 min. rest	7.6	43.1	16.8	41.7
W		2 min. study checker-board of numbers; rest		37.5		37.5

The evidence for inhibition in these results is so slight as to be negligible. Tolman concludes: "In short, DeCamp's completely negative findings tend to be supported. We conclude that this comparison of normal and distracted attention did not present the contrast between a condition more susceptible to inhibition and one less susceptible to inhibition which we were looking for" (p. 30).

Two experiments followed on the comparison of the "with caffeine" and "without caffeine" conditions. These experiments are summarized in Table 11.

Table 11. Conditions and Results of Tolman's Experiments 6 and 7.

Exp.		n	Interpolated Interval	With Caffeine RL	With Caffeine %R	Without Caffeine RL	Without Caffeine %R
6	R	48	7½ min. rest	9.5	37.5	10.5	50.0
	W		2 min. study checkerboard of numbers; rest		41.7		27.1
7	R	72	7½ min. rest	15.0	41.7	13.8	55.6
	W		2 min. study checkerboard of numbers; rest		29.2		30.6

The results of both experiments show some evidence of greater inhibition on the "non-caffeine" days than on the "caffeine days."

From the data obtained in Experiments 8, 9, 10, 11, 12, and 13 comparisons were made of the influence of retroactive inhibition under "efficient" and "inefficient" conditions, i.e., morning and evening study, or morning and afternoon study. The results are shown in Table 12.

Tolman's own conclusion from these six experiments is: "Without exception the lists learned

Table 12. Conditions and Results of Tolman's Experimnts 8-13.

Exp.		n	Interpolated Interval	Morning RL	Morning %r	Evening RL	Evening %R
8	R	50	8½ min. rest	9.5	44.0	21.8	52.0
	W		2 min. study checkerboard of numbers, rest		42.0		34.0
9	R	30	8½ min. rest	9.3	36.7	12.5	43.3
	W		2 min. study checkerboard of numbers; rest		26.7		26.7
				Morning		Afternoon	
10	R	30	8½ min. rest	9.7	50.0	14.8	50.0
	W		2 min. study checkerboard of numbers; rest		36.7		23.3
11	R	30	8½ min. rest	9.0	56.7	14.0	56.7
	W		2 min. study checkerboard of numbers; rest		43.3		26.7
12	R	30	8½ min. rest	7.2	66.7	9.0	66.7
	W		2 min. study checkerboard of numbers; rest		60.0		50.0
13	R	50	8½ min. rest	4.5	54.0	8.4	68.0
	W		2 min. study checkerboard of numbers; rest		56.0		48.0

in the inefficient hour of the day showed more inhibition, in terms of percentages of correct responses, than did those learned in the efficient hour of the day" (p. 39).

Briefly stated, the results of all of Tolman's experiments seem to indicate greater inhibition under what he calls the "less stimulating conditions of learning," i.e., learning indifferent material, learning without caffeine, or learning in an inefficient hour of the day, than under the "more stimulating conditions."

Robinson (20) (21) (22) (23).

In his first study Robinson concerned himself with the problems of the effect of similarity and dissimilarity of the original and interpolated activities, of temporal position, and of the degree of learning upon retroactive inhibition.

Three experiments were made to study the first condition. In two of these the original problem was the learning of series of eight four-place numbers. The third was made with the reconstruction method, a chess board and six chess men being used. The interpolated activities were: (1) memorizing a second list

of four-place numbers; (2) memorizing 20 consonants; (3) memorizing poetry; (4) solving four-place by four-place multiplication problems; and (5) reading simple narrative prose. In Experiment 2 a sixth activity was introduced, the study of pictures of nudes, which was intended to introduce the factor of affective tone.

Three criteria of recall were used: (1) amount of recall, (2) error of recall, and (3) time, which was the total time for reproduction divided by the number of digits given in the reproduction. The results, which are shown in Table 13, indicate a greater amount of inhibition where the work consisted in the learning of a second series of numbers than in any other condition. Reading produced the least deleterious effect.

In Experiment 4 the effect of temporal position was studied. Material for original learning consisted of lists of 10 three-place numbers, displayed on a hand operated drum. The 20 minutes of interpolated activity were used as is shown in the summary of conditions and results given in Table 14. From these results it would seem that temporal position plays no important

Table 13. Conditions and Results of Robinson's Experiments 1 and 2.

Exp.	Interpolated Interval (3 minutes)	Amount Recall (digits)	Error Recall	Time Secs.
1	Studying numbers	15.4	27.5	5.73
	Consonants	22.4	17.4	3.07
	Poetry	21.9	19.3	3.57
	Multiplication	22.1	15.7	3.55
	Reading	22.8	16.5	
2	Four-place numbers	15.3	33.8	5.50
	Digits	18.2	22.4	4.30
	Multiplication	20.6	21.5	4.08
	Pictures of nudes	21.4	22.3	3.15
	Reading	21.4	19.1	3.38

part in influencing the susceptibility to retroactive inhibition.

Individual records kept for the subjects indicate that there is a tendency for practice to lower susceptibility to inhibition. This was also indicated in the chess experiment, where a practiced chess player showed less inhibition than did those who had not played.

In the study of the effect of the degree of learning upon the amount of retroaction the conditions were the same as in Experiment 4 except that the number

Table 14. Conditions and Results of Robinson's Experiment 4.

Exp.	Interpolated Interval	Amount Recall (digits)	Error Recall	Time Secs.
4	20 min. reading	29.1	6.1	1.6
	5 min. study second list; 15 min. reading	18.6	31.9	5.9
	5 min. reading; 10 min. study second list; 5 min. reading	19.7	29.0	5.5
	10 min. reading; 5 min. study second list; 5 min. reading	19.2	32.6	6.4
	15 min. reading; 5 min. study second list	18.4	30.3	6.9

of repetitions was varied and the time kept constant. The results show the relative amount of loss under the various conditions. This is determined by dividing the difference in efficiency between rest and work conditions by the efficiency under the rest condition. It is evident that within the limits here studied the results indicate that the number of repetitions, or the degree of learning, has no general tendency to increase or decrease the amount of inhibition.

Table 15. Conditions and Results of Robinson's Experiment on the Degree of Learning.

Presentations	Amount of Inhibition	Time Secs.	% Error
4	59.3	233	26
6	56.6	152	73
8	45.4	115	98
10	45.3	176	156
12	45.3	367	117

The conclusions drawn from this study are as follows:

1. Similarity of contents, of processes, and of forms of presentation all play a part in determining the degree of retroactive inhibition.

2. The degree of retroactive inhibition is independent of the temporal position of the interpolation.

3. Practice in memorizing a particular kind of material may decrease one's susceptibility to retroactive inhibition.

4. Within the limits studied there is no single, continuous relationship between the number of presentations of a memorized material and its absolute susceptibility to retroactive inhibition.

Robinson worked with Darrow and Heron in two further studies (22) (23) which deal with the length of lists and susceptibility to retroactive inhibition, using in one nonsense syllables, and in the other, numbers as the original learning material. In the first study 10 subjects were used, each serving three times in 10 different conditions. The conditions were those of the regular work and rest tests for five different lengths of series, 6, 9, 12, 15, and 18 syllables. Interpolated work consisted in studying a new series of 12 syllables. The interpolated period was 15 minutes in length.

In the number test 10 subjects were put through eight conditions four times. The lists were made up of four, six, eight, and 10 three-place numbers. Interpolated work consisted in learning a new series of six three-place numbers (15 minutes study). During the rest intervals the subject read the newspaper. The averages of the recall records of 10 subjects are given in Table 16. Each subject served in three experiments under each condition. Absolute inhibition was determined by subtracting the recall

Table 16. Conditions and Results of Robinson's Experiments 9 and 11.

Repetitions	Inhibition	
	Absolute	Relative
Nonsense Syllables		
6	25.2	33.3
9	21.6	27.2
12	16.9	24.7
15	13.8	17.2
18	16.1	18.6
Numbers		
4	30.8	51.3
6	45.0	68.1
8	34.1	52.0
10	23.9	32.8

under the work condition from the recall under the rest condition. Relative inhibition is the percentage which the absolute inhibition is of the recall under the rest condition. The results of both experiments show a decreasing susceptibility to retroaction as the lists increase in length, with some evidence of a lower limit of the law.

Robinson (21) has recently given further attention to the similarity factor in retroaction. He objected to the former studies because of the fact that

there could be no measurement of the similarity or difference between the materials used, i.e., nonsense syllables, digits, three-place numbers, poetry, reading, etc. Such materials can only be ranked on a similarity-dissimilarity scale. Robinson made two experimental attacks upon the problem of similarity where he ruled out this difficulty. In the first study he used "a number of tasks of memorization each of which could be described in terms of a simple physical magnitude. S was presented with a line of a given length. An interpolated period followed during which a second line was presented. S reproduced the first line by drawing immediately after he had seen the second and, after that, reproduced the second. (The second was reproduced in order that S would not neglect paying attention to the interpolated line upon later repetition of the experiment.) Every S went through these conditions on numerous occasions so that there finally accumulated considerable data showing the influence on the length of the interpolated line upon the memory for an original line of a given length. (Several standards were used.) Suffice it to say that there was no discernable rela-

tionship between retention and similarity of interpolation to original learning. In fact the retention of such a simple sensory fact as the length of a line seems to be peculiarly resistant to retroaction" (p. 303).

In the main investigation Robinson used consonants as learning material. Three experiments were conducted in which from 16 to 20 graduate students acted alternately as S and E. In the first experiment the material consisted of four consonants for original learning and four for interpolation. These were presented to S visually (0.5 sec. exposure) as a continuous list of eight consonants. Recall was written, and the records obtained were divided into original and interpolated lists as in the ordinary retroaction experiments. The degree of identity between original and interpolated material was varied as in the following scheme:

Degree of Identity	Arrangement of Consonants
None in common	a b c d e f g h
One in common	a b c d a f g h
	a b c d e b g h
	a b c d e f c h
	a b c d e f g d

Two in common	a	b	c	d	a	b	g	h
	a	b	c	d	a	f	c	h
	a	b	c	d	a	f	g	d
	a	b	c	d	e	b	c	h
	a	b	c	d	e	b	g	d
	a	b	c	d	e	f	c	d
Three in common	a	b	c	d	a	b	c	h
	a	b	c	d	a	f	c	d
	a	b	c	d	a	b	g	d
	a	b	c	d	e	b	c	d
Four in common	a	b	c	d	a	b	c	d

There were thus 16 conditions. At any given sitting each S studied a list representing each one of these experimental conditions. Sixteen different orders of presentation were obtained by shuffling and dealing cards. The results are given in terms of the percentage of recall of the first four consonants. In order that differences developing during the progress of the experiment might be detected, the nine full repetitions of the experiment were divided into successive thirds. Some account had to be taken of the fact that certain conditions appeared in the program oftener than others. The conditions of none-in-common and of four-in-common occur once each and they furnished a base to which the others were made equivalent by division. For instance, the

records made under the one-in-common conditions was divided by four and thus made comparable with those made under the conditions of four- and none-in-common.

The results for a single cycle of the experiment are based on three performances for every S under each experimental condition, therefore N is equal to 60. The results are shown graphically in Figure 1. They show that only in the first cycle is there the inversion that is supposed to exist in the relationship between similarity and retroaction. This may indicate that perhaps the "theoretical function holds only for situations that are very novel to S." (p. 306).

Experiment 2 was a repetition of Experiment 1 except that the material was presented auditorily at the rate of two consonants a second. Results are essentially the same as those of Experiment 1.

In Experiment 3 the task was made more difficult. The lists were made up of 12 consonants, six for the original, and six for the interpolated list. There were thus 64 conditions. Each of the 16 subjects went through 16 of these conditions on any one experimental day. Again the results are divided into cycles and are

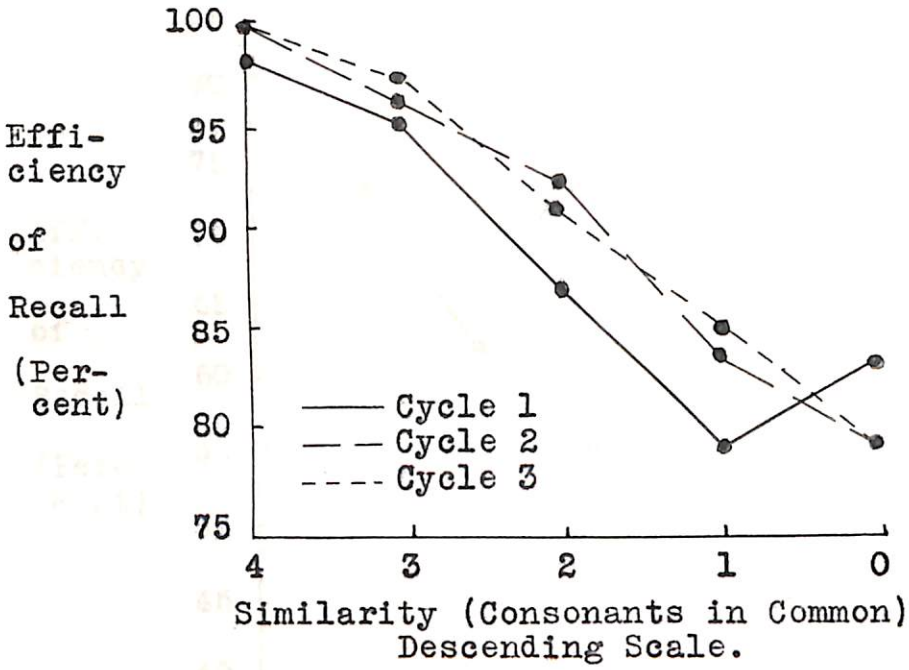


Figure 1. Results of Robinson's Experiment 1 by Individual Cycles. Visual Presentation.

presented graphically in curves very similar to those of Figure 1. Only in one cycle, the fourth, is the inversion found. This inversion, according to Robinson, "has everything about it to suggest statistical accident" (p. 312). The averages of the results of Experiment 3 are given in Figure 2.

Robinson concludes that it is safe to say "that under such circumstances as we have worked we have shown that the theoretical relationship does not hold

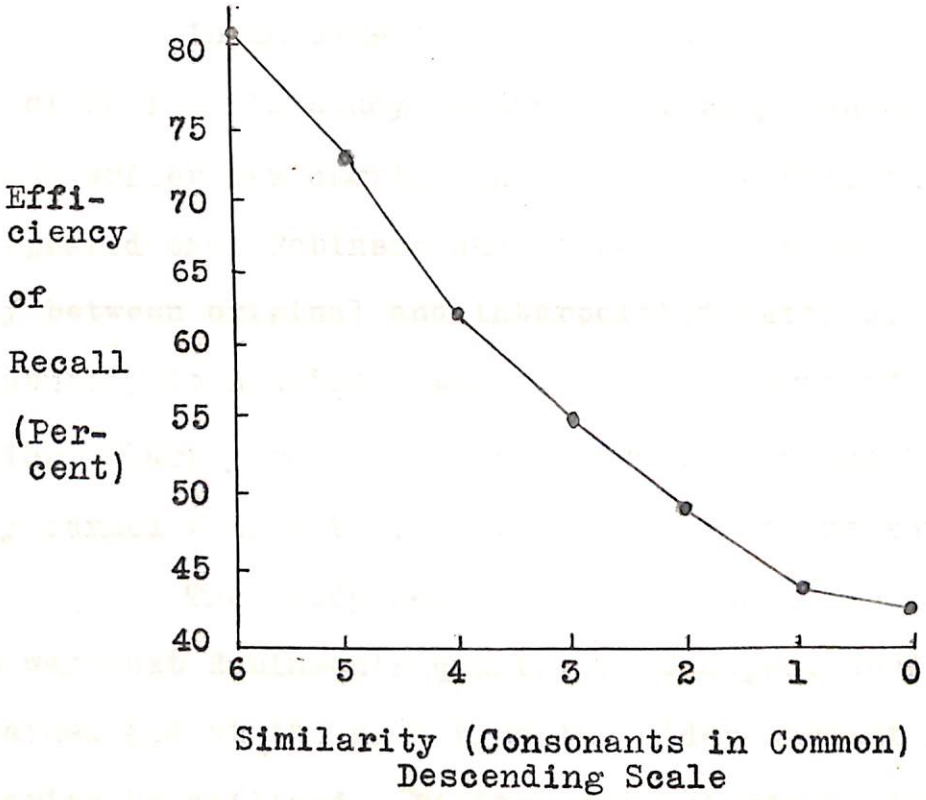


Figure 2. Results of Robinson's Experiment 3. Average for Entire Experiment.

as often as a simpler one. In other words, however many may be the conditions under which there is a first order inversion in the debated function, there are demonstrable conditions under which such inversion is absent" (p. 312).

Harden (6).

In an experiment which was designed to supplement Robinson's study of the similarity factor, the present writer has carried that study one step further. It appeared that Robinson had varied his degree of similarity between original and interpolated material only from identity to non-identity. Thus his degree of greatest dissimilarity really corresponded to what he had formerly termed similarity, i.e., material of the same type.

The study here described was planned in such a way that Robinson's quantitative aspect could be maintained and at the same time the older concept of similarity be utilized. Digits were introduced into the series of eight items. The plan then became that shown in the following scheme:

Degree of Similarity	Arrangement of Items
None in common	a b c d 1 2 3 4
One in common	a b c d e 2 3 4
	a b c d 1 f 3 4
	a b c d 1 2 g 4
	a b c d 1 2 3 h
Two in common	a b c d e f 3 4
	a b c d 1 f g 4
	a b c d 1 2 g h

Two in common (continued)	a	b	c	d	e	2	g	4
	a	b	c	d	1	f	3	h
	a	b	c	d	e	2	3	h
Three in common	a	b	c	d	e	f	g	4
	a	b	c	d	1	f	g	h
	a	b	c	d	e	2	g	h
	a	b	c	d	e	f	3	h
Four in common	a	b	c	d	e	f	g	h

Instead of using the first and last conditions as the base and dividing the others by four or six as Robinson did, the two-in-common condition was taken as a base and six lists were prepared for each condition. There were thus 30 lists. Ten subjects served in the experiment and each studied the entire 30 lists at each of four experimental sittings. The method and conditions of the experiment approximated those of Robinson's as closely as possible.

The results are shown in Figure 3, upon which Robinson's results have also been plotted in order to make the relationship between the two sets of data more clear. These results indicate that recall is more efficient when the original and interpolated materials are most dissimilar than when these materials are similar or mixed. When combined with the results of Robinson's

experiment they indicate that the theoretical relationship represented in the following curve (Figure 4) is true in part.

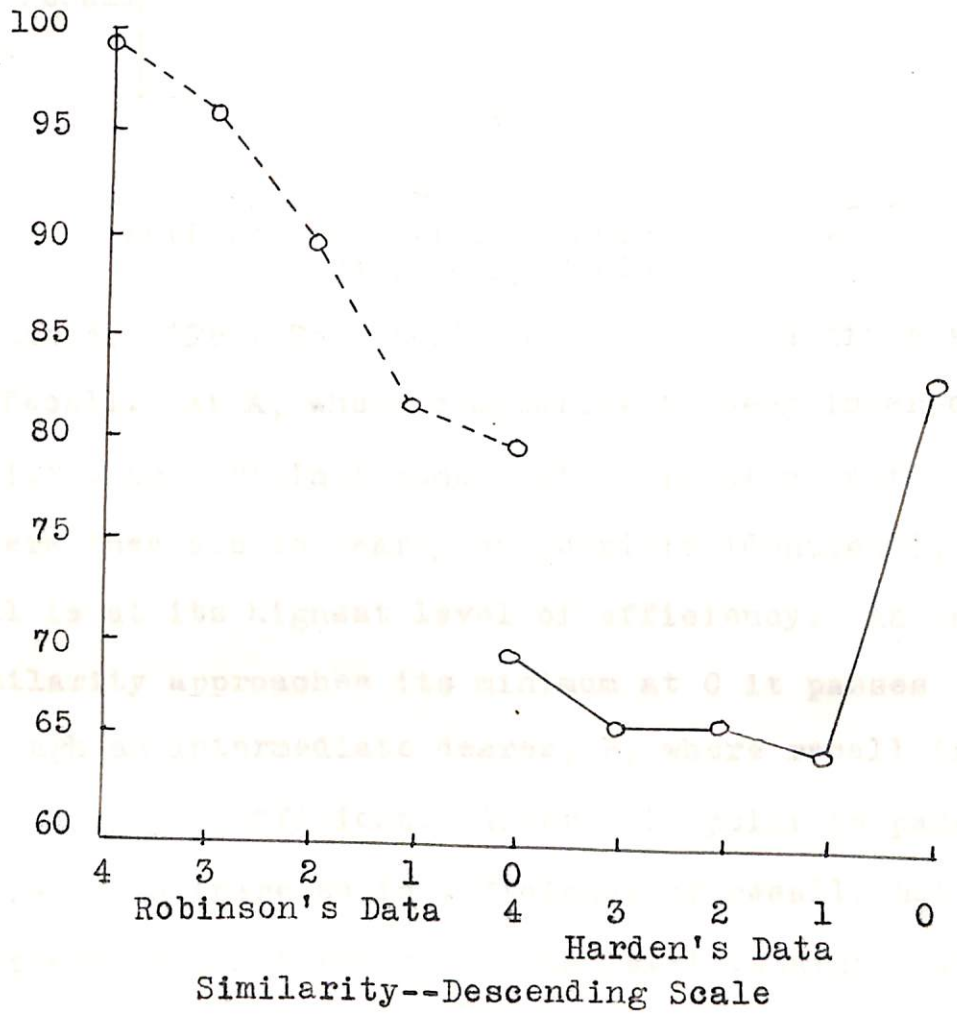
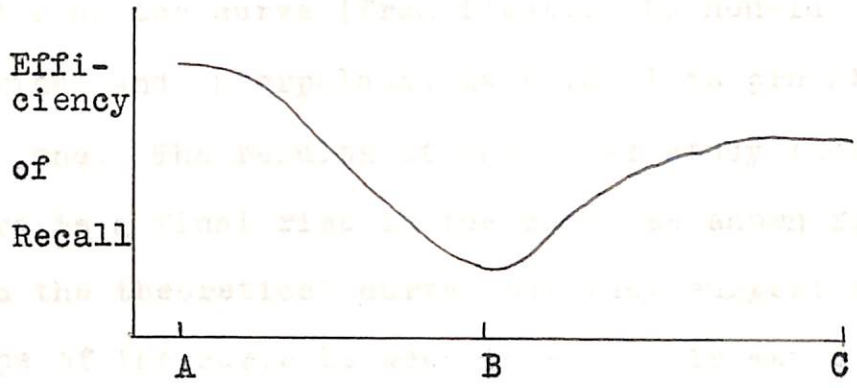


Figure 3. Results of Robinson's and Harden's Experiments.



Degree of Similarity between Interpolated Activity and Original Memorization--Descending Scale

Figure 4. (From Robinson) Similarity and Efficiency of Recall. At A, where similarity between interpolated activity and original memorization is at a maximum (where they are as nearly as possible identical), recall is at its highest level of efficiency. As this similarity approaches its minimum at C it passes through an intermediate degree, B, where recall is exceedingly inefficient. After this point is passed, there is an increase in efficiency of recall, but this increase does not return to the level obtaining at A.

Robinson's results show that the relationship shown from A to B on the curve (from identity to non-identity of original and interpolated materials) is probably the true one. The results of the later study indicate that there is a final rise in the curve as shown from B to C on the theoretical curve, but they suggest that the shape of the curve between these points may be concave rather than convex.

It was suggested by remarks of subjects and by some experimental data that the relative difficulty of the interpolated material may have been a factor in determining the degree of inhibition shown in the results of this study. Further work has been planned to determine if this was the case.

Skaggs (24).

Another extensive study of retroaction is that of Skaggs, who has dealt with several major problems: (1) the evidence for retroactive inhibition, (2) the effect of temporal position, (3) the effect of similarity and dissimilarity of original and interpolated

activity, and (4) the effect of fatigue, which is a comparison of results of morning and evening studies.

Skaggs used as original learning activity the study of arrangements of five chess men, series of disconnected sense words, and series of nonsense syllables. The retention of the chess arrangements was tested by the reconstruction method, while the retention of the words and syllables were tested both by the simple recall and by the right associates methods. The subjects were divided into three groups according to their experience in introspection: trained, semi-trained, and untrained. In the reconstruction test the arrangement of chess men was exposed for 15 seconds. The sense words were exposed serially at the rate of one per one and a half seconds by moving a long covering cardboard, which contained a small lateral window, down a card on which the words were printed. The exposure was timed by a silent pendulum.

Four experiments dealt with the comparison of work and rest intervals. These experiments are summarized in Table 17. The data show some evidence of

Table 17. Conditions and Results of Skaggs' Experiments on the Presence of Retroaction.

Reconstruction Test

	n	Interpolated Interval	Errors	M.V.	Time Secs.	M.V.
R	156	½ min. rest	4.21	.61	55.95	3.38
W		½ min. adding	8.55	.45	65.66	10.98
R		1 min. rest	5.95	1.27	55.55	17.53
W		1 min. adding	9.04	2.07	66.01	19.85
R		2 min. rest	6.88	2.24	57.05	20.20
W		2 min. adding	9.42	3.53	74.01	26.12

(M.V. refers to mean variation.)

Sense-Word Test

	n	Interpolated Interval	%R	Error	Time Secs.
R	37	1 min. rest	6.20	0.63	65.0
W		1 min. adding	5.69	0.50	68.7

Nonsense Syllables: Recall Method

R	84	3 min. rest	4.10	0.64	77.4
W		3 min. mathematical test	3.39	0.52	74.9

Nonsense Syllables: Right Associates Method

				(Sigma)
R	5 min. rest	3.54	1.43	5283
W	5 min. dissimilar work	3.89	0.98	5548.
	5 min. similar work	3.39	1.44	5452

inhibition. In the right associates test with nonsense syllables, there is the least indication of loss, in fact, so little as to be negligible. The method by which these results were obtained was much like DeCamp's and 15 repetitions were given for original learning. It seems possible that the material was overlearned.

Records taken in the morning and in the evening, also the first and last of a day's series, were compared to determine the effect of fatigue. The reconstruction test alone was used in this group of experiments. The trained subjects showed no more tendency to retroaction in the evening than in the morning. A comparison of the first and last tests in a series seems to indicate some increase of retroaction in the last tests, but whether this was due to fatigue or to lack of continued interest or interference of the learning immediately preceding could not be made clear.

The effect of practice was determined by a comparison of the averages of the first half of an entire series of 20 experiments for five trained subjects with the averages for the last half of the series. The

results of the experiments using the reconstruction method are presented for individuals, but are too complicated to be reproduced here. Out of 23 possible comparisons 11 show greater retroaction for the first half, 10 for the latter half, and two are so close that they may be regarded as neutral. No definite conclusion can be drawn.

A comparison of the first and last results obtained when using sense words shows a slight tendency for retroactive inhibition to increase with practice, but the work is too limited for any general conclusions to be drawn.

In studying the effect of varying the temporal position of interpolation several methods were employed. In the experiments involving the use of sense words as original learning only two subjects worked. The records were diametrically opposed, those of one subject showing less inhibition where rest followed learning, those of the other, when work followed the learning immediately.

Two studies were made using nonsense syllables, one with the simple recall method and one with the right associates method. Average results for five subjects

are given in Table 18. These results seem to show that

Table 18. Conditions and Results of Skaggs' Experiments on Temporal Position.

n	Interpolated Interval	RL	%R	Error	Time Secs.
162	3 min. rest; 3 min. work, arithmetic or algebra	3	3.22	0.58	73.8
	1 min. rest; 3 min. work; 2 min. rest		3.75	0.38	62.6
	3 min. work; 3 min. rest		2.79	0.70	71.4

the temporal position of the work is important. However, a control experiment with 13 untrained subjects gave doubtful results. These are shown in Table 19. Time

Table 19. Conditions and Results of Skaggs' Experiment on Temporal Position with 13 Untrained Subjects.

n	Interpolated Interval	RL	%R	Error	Time Secs.
52	2 min. rest; 3 min. work; o min. read magazine	3	2.95	0.85	67.3
	3 min. work; 2 min. rest; 1 min. read magazine		2.72	0.80	57.3

records alone give a significant indication that the effect is greater when work follows immediately than when it follows after an interval of rest. Of the individual records, seven showed more retroaction for the immediate work interval, while six showed more for the immediate rest interval.

The right associates method gave the results shown in Table 20.

Table 20. Conditions and Results of Skaggs' Experiment on Temporal Position using the Right Associates Method

n	Interpolated interval	RL	%R	Error	Time Sigma
49	3 min. rest; 3 min. work; 1 min. looking at catalog	3	3.98	1.38	3184
	3 min. work; 3 min. rest; 1 min. looking at catalog		3.67	1.37	3309

The time record again indicates retroaction. The other records show too little loss to justify the drawing of any conclusions, although Skaggs does say that a careful analysis of the above results justifies us in saying that the temporal position is important--with apparent

individual exceptions.

The final question which Skaggs studied was that of the effect of similarity or dissimilarity of the original and interpolated materials upon the degree of retroaction. The reconstruction test and nonsense syllables were used. The averages for five subjects on the reconstruction test are shown in Table 21. Robinson's original findings are confirmed by these results. It appears that the effect of the interpolated material varies with the degree of similarity between the original learning and the interpolated material.

The right associates method was used in one experiment with nonsense syllables and showed very little evidence of retroaction. Single syllables with the simple recall method showed retroaction in the records of correct recall and of errors, but not in the time records.

From this series of experiments Skaggs draws the following conclusions:

1. All the tests except the paired associates show greater inhibition when work follows learning than when rest follows.

2. All tests (except reaction time for paired associates) show the importance of similarity and dissimilarity of original learning and interpolation in this relation:

"A. When interpolation and learning are identical there is only reinforcement or repetition.

"B. As the material is made (by degrees) more and more dissimilar the reinforcing factors gradually diminish in effectiveness and the interfering factors become more and more pronounced.

"C. As the material of learning and work is made more dissimilar a point is reached where there is a maximum of interference or detrimental influence wrought upon the original learning.

"D. Beyond this point the curve of interference goes downward, and then we can say that the more dissimilar the materials the less the detrimental influence.

"E. However, the curve of detrimental influence never reaches zero because after the work and learning are as different as they can possibly be made there is still a damaging influence exerted by the

Table 21. Conditions and Results of Skaggs' Experiments on the Similarity Factor.

n	Interpolated Interval	Errors	Time Secs.
50	1. New chess formation (Similar work)	13.05	62.4
	2. Formation on white cardboard with black lines of large white button, black button, red checker, and a pawn (Intermediate work)	9.24	60.4
	3. Multiplication (Dissimilar work)	9.75	64.5
	4. Study post card pictures (Dissimilar work)	7.10	34.5
	Averages for Nine Subjects		
45	1. Similar work (as above)	11.44	59.6
	2. Intermediate (as above)	8.7	51.7
	3. Dissimilar (as above)	6.1	42.5

work.

"3. The data accumulated indicate that the temporal position of the interpolated work is important

"4. On the basis of the data from the reconstruction experiments there seems to be evidence that as

the subject becomes more and more fatigued in the course of the day's series the work activity acts relatively more detrimentally upon the original learning" (p. 58).

5. The data regarding the effect of practice are not clear.

Whitely (28) (29) (30).

In his early study of the dependence of learning and recall upon prior conditions, Whitely studied the influence upon recall of mental and physical activities introduced immediately preceding recall. The material to be learned consisted of series of 18 three- and four-letter monosyllabic words. Interpolated physical work consisted of calisthenic exercises; and the mental work, of simple multiplication. The results indicate no general influence of retroactive inhibition. Only two subjects of the 15 showed detrimental effects of the interpolated work.

In another study this author investigated the dependence of recall upon intellectual activities aroused at different intervals prior to that recall. Original learning material consisted of lists of 18

words or phrases bearing the connotation of a certain background of knowledge (Bible, Revolution, etc.). Interpolated activity consisted either of reading résumés or taking a "question-associational" test on one of the various fields to which the sets of words applied. The experiments were conducted as group tests. Over 1000 individuals participated, including grammar school, high school, and college students.

The first experiment was designed to answer these three questions: (1) Is the arousal of an apperceptive set effective in influencing recall? (2) Is the degree or character of the influence a function of the relation of the apperceptive system to the memorial material? (3) Is the effectiveness of an apperceptive system in influencing recall dependent upon the age or school standing of the subjects? The subjects studied a given list of words for two minutes and were allowed two minutes for written recall. Twenty-four hours later (48 hours in the case of the college students) they were given another written recall, but immediately before this recall they were given either (1) no apperceptive arousal, (2) apperceptive set by reading a résumé or

taking an association test in the same field (congruous relation), or (3) apperceptive set in another field (non-congruous relation). The results are given in Table 22. Here "Ave." represents the average number of

Table 22. Conditions and Results of Whitely's Experiments on the Similarity Factor.

	College Students						
	Learning			Recall			
Condition	Ave.	%Err.	N	Ave.	%Err.	N	% R of L
None	12.3	.8	44	10.7	5.3	41	76.6
Congru.	12.6	1.1	38	8.1	10.9	36	61.6
Non-Con.	12.5	.7	38	9.1	6.1	36	67.5
	High School and Grammar School Students						
None	11.2	.5	42	9.8	4.0	43	87.5
Congru.	10.8	.7	35	7.6	12.4	34	70.4
Non-Con.	10.8	1.1	31	8.8	6.8	30	81.5

words recalled; "%Err.," the percentage error in the recall; "N" is the number of cases;"% R of L" gives the ratio between the average number recalled in the recall test and the average number recalled in the learning test.

It may be concluded from the results pre-

sented in Table 22 that:

1. The arousal of an apperceptive set does influence recall.

2. The degree of influence is a function of the relationship between the apperceptive system and the memorial material; the congruous material has a more detrimental effect than uncontrolled activity or non-congruous material.

3. The influence is not a function of age or of scholastic standing, both college students and grammar and high school groups showing a similar effect.

The second experiment involved two problems: (1) a further study of the inhibitive influence of congruous material, and (2) the determination of whether or not this influence is a function of the time interval between learning and recall. Four groups of college students served in this experiment, two as experimental groups and two as control groups. All learned the "Revolution" set of words under the same conditions. After 48 hours one control group recalled with no controlled activity preceding the recall and one experimental group recalled following an association test on

the Revolution. The other two groups recalled under similar conditions 96 hours after the original learning. Table 23 summarizes conditions and results. Again the

Table 23. Conditions and Results of Whitely's Experiment on the Similarity Factor.

	Learning			Recall			
Condition	Ave.	%Err.	N	Ave.	%Err.	N	% R of L
None (48)	12.9	.2	41	11.6	2.4	38	90.0
Rev. (48)	12.5	1.2	46	8.3	10.5	45	66.4
None (96)	12.8	1.0	38	10.1	5.3	32	78.1
Rev. (96)	12.8	.7	43	7.1	3.4	38	55.5

arousal of a congruous apperceptive system is more disturbing than uncontrolled activity prior to recall for both groups. The results are inconclusive with reference to the relation of the inhibitive effect to the degree of retention.

A third experiment dealt with the effect of temporal position, i.e., whether or not the influence of an apperceptive system upon recall is a function of the time interval between the arousal of the apper-

ceptive set and the recall. The arousal of apperceptive set was used at three positions, prior to learning (Prior L in the following table), immediately after learning (After L), and immediately prior to recall (Prior R). Forty-eight hours elapsed between learning and recall. Table 24 shows the results. The conclu-

Table 24. Conditions and Results of Whitely's Experiments on Temporal Position.

	Learning			Recall			
			Congruous Material				
Condition	Ave.	%Err.	N	Ave.	%Err.	N	% R of L
None	12.1	1.5	35	7.4	8.6	32	61.1
Prior R	12.7	.7	32	5.5	17.8	30	43.7
Prior L	12.1	2.3	37	6.4	12.4	35	52.9
After L	13.2	1.3	30	7.2	10.2	29	54.6
None	12.1	1.7	39	7.8	13.8	34	65.3
Prior R	12.2	2.4	34	5.9	18.3	32	48.2
After L	11.4	3.6	34	6.0	18.3	34	52.7
			Non-Congruous Material				
None	12.1	1.7	39	7.8	13.8	34	65.3
Prior R	12.2	1.6	30	6.7	13.0	30	54.4
After L	10.8	2.6	44	7.1	11.4	39	66.0

sions drawn from these results are:

"1. A congruous system exerted the greatest

inhibitory effect when introduced immediately preceding recall in three of four comparisons in respect to both percentages of recall and percentages of error.

"2. It also exerted a greater effect when introduced prior to the act of learning than immediately after learning in three of the four comparisons and in the total averages for both percentages of recall and percentages of error" (p. 505).

The reliability of the data is presented, and the author points out that if we accept a difference which is three times its sigma, only eight out of 26 comparisons are reliable when taken singly. "The consistency of results, however, does indicate some degree of reliability" (p. 505).

McGeoch (15) (16).

A recent study by McGeoch deals with the influence of the degree of learning upon retroaction. The effect of five degrees of learning was determined, i.e., 6, 11, 16, 21, and 26 repetitions. The learning materials were nonsense syllables in nine-syllable lists, exposed on a Chicago memory drum at

the rate of two seconds per syllable. They were learned by the anticipation method. Records made under rest and work conditions for each of the five degrees of learning are compared. During the interval between learning and relearning in the work condition the subjects learned a new list of syllables. Eight graduate students and two members of the Department of Psychology served as subjects. Each went through all degrees of learning under each condition twice in a counterbalanced practice order. Retroaction was measured in terms of the relative differences between the rest and work conditions for both recall and relearning scores.

The computation of overlearning ratios showed that the increase in number of presentations meant a corresponding increase in the degree of learning. With the larger numbers of presentations overlearning was very great. The relative amount of retroactive inhibition, measured in terms of both recall and relearning scores, varies inversely as the number of presentations given the material to be learned. Even lists learned to 26 repetitions, however, suffered a considerable

disintegration from the interpolated lists. The tendency for retroaction to decrease as the degree of learning increased applies to serial positions in the list differentially, the position of the maximum amount of inhibition shifting as the degree of learning increases.

Hinrich (8).

Hinrich studied the phenomenon of retroactive inhibition in children. His subjects were 10 boys, nine to 13 years in age. Ten monosyllabic words were used as original learning. Studying number squares was the interpolated activity for the work condition. The time plan was as follows:

Study list 3 min.	Study number squares 5 min.	Rest 5 min.	Test	(W)
Study list 3 min.	Rest 10 min.			(R)

The results are given in Table 25. The numbers apparently refer to the number of words recalled in the W and R series. Since 100 words were learned by each subject in the series of experiments, these may also be read as percentages. The results indicate clearly

the presence of the factor of retroactive inhibition in the learning of these children.

Table 25. Results of Hinrich's Experiment with Children.

Subject	1	2	3	4	5	6	7	8	9	10
R	47	46	42	30	40	46	48	62	44	33
W	28	23	32	20	29	36	35	57	29	48

Lund (14).

Lund has touched upon the question of retroactive inhibition in recognition memory. His investigation dealt with the degree of confidence in recognition memory. Ten five-letter nonsense words (Series A) were presented tachistoscopically at 10-second intervals to each subject. Immediately afterward this series was again presented in a list composed of Series A, Series B (a list which duplicated Series A except that one letter was changed in each word), and Series C (another list which duplicated Series A except that two letters were changed in each word). This composite list was presented in two orders, one in which a word of Series B always preceded a word from Series A, and one

in which the order was reversed. The results showed greater recognition and confidence when Series A words preceded the Series B words than under the reverse condition. This, the author says, is probably most easily explained by retroactive effects. Such an explanation assumes that retroaction may occur in recognition memory.

Jenkins and Dallenbach (10).

Jenkins and Dallenbach have found experimentally that the reproduction of nonsense syllables is much better after an interval of sleep than after an equal interval of waking. Two O's were used and the time intervals employed were one, two, four, and eight hours. The results led the authors to conclude "that forgetting is not so much a matter of decay of old impressions and associations as it is a matter of interference, inhibition, or obliteration of the old by the new" (p. 612).

These writers have reported the only material on the effect of hypnosis upon retroactive inhibition. They used only one subject who was hypnotised during

the learning process and again during the reproduction of the material after two, four, eight, and 24 hour intervals. The O correctly reproduced a series after the two, four, and eight hour intervals and correctly reproduced 10 out of 12 syllables after the 24 hour interval. Moll (18) had reported Wienholt as stating that "memory was intensified in the magnetic sleep," which would be in agreement with the results of Jenkins and Dallenbach. On the other hand, Moll reported that Beaumis and Dessoir found contradictory results.

Dahl (3).

Jenkins and Dallenbach's findings on the effect of sleep have been at least partially confirmed by Dahl who found that both nonsense syllables and figures were recognized better after six and eight hours of sleep than after equal intervals of waking. In the one and two hour intervals, however, the recognition after the waking interval was better when measured by the total errors and by the number of errors when new material in the test list was reported as

recognized. The latter errors were frequent after these short intervals of sleep and all but lacking after equal intervals of waking (14 and 19% more after sleeping than after waking for the one and two hour intervals, respectively; and 4% less for both the six and eight hour intervals). On the other hand, the recognition after sleep was superior after all intervals of sleep when the criterion was the number of errors where the original syllables were not recognized. Only by this one criterion then were the results which Jenkins and Dallenbach obtained with the recall method confirmed. Dahl used 12 subjects.

Comparative Studies.

There have been three comparative studies in the field of retroactive inhibition. Webb worked with human subjects and rats, while Brockbank and Hunter and Yarborough worked only with rats.

Webb (27).

Webb studied the effect of interpolated acti-

vities upon the retention of motor habits. Mazes were used for both original learning and interpolation. The human subjects used pencil mazes, while the rats were trained on a series of adjustably mazes.

The subjects were divided into 10 groups, five of which were used as test groups and five as control groups. There were five individuals in each group of human subjects and from seven to 12 in each group of rats. A test and a control group were trained on a variation of the maze (B, C, D, E, or F). The control group then rested, while the test groups were trained on Maze A. The retroactive effect was measured by the difference in the records of time, trials, and errors in relearning the original maze (B, C, D, E, or F).

In a second experiment the mastery of Maze A was the original problem, while the training of each group to another maze (B, C, D, E, or F) served as interpolation. Thirty days after learning the new maze all subjects were retrained on Maze A. The control groups in this case learned Maze A and then rested until the time for relearning.

Webb's conclusions from these experiments are as follows:

"1. The greater degree of disintegration occurred with the test groups.....

"2. The existence of retroaction is a function of the individual.....

"3. Human subjects are more susceptible than rats to the disintegrating effect of retroactive influences.....

"4. The degree of retroactive inhibition is a function of the interpolated maze activity. The easier is the maze to learn, the greater is the resulting negative retroaction" (p. 80).

Brockbank (1).

Brockbank used mazes as original learning, with the rope-ladder problem as the interpolated activity. Comparison was again made between the records of a test and a control group for relearning the maze. This comparison showed no evidence of inhibition for the test group. A comparison of the results of Webb and Brockbank seems to indicate that the similarity or

dissimilarity of interpolated activity and original learning may also be an important factor with rats, as Robinson and Skaggs have shown it to be with human subjects.

Hunter and Yarborough (9).

Hunter and Yarborough dealt with the interference of auditory-motor habits in the white rat. Twenty rats were trained to turn right for handclaps and left for silence in the ordinary T-shaped discrimination box. All the rats learned the problem in from 210 to 710 trials.

The general plan of the work was as follows:

A. Twenty rats (Set A) were trained to turn right for handclaps, left for silence.

B. Four rats of Set A were trained for 30 days to turn right for a buzzer.

C. Four rats of Set A were trained for 30 days to turn right for a tuning fork.

D. Four rats of Set A were trained for 30 days to turn left for a tuning fork.

E. Four rats of Set A were trained for 30 days on the

regular presentation of auditory stimulus.

F. Four rats of Set A were tested for retention after 30 days rest.

G. Rats of Groups B, C, D, and E were tested on the original problem,--to turn right for handclaps, left for silence.

Comparison was made of the relative retention of the first problem for all the groups. This showed no indication of the influence of retroactive inhibition, but rather of a "forward reference," an interference of the first habit in the forming of the second. The authors' statement of the problem is this: "We have brought to light no evidence that learning the second habit as such interferes with the retention of the first habit. It seems clear that in some cases the lapse of time may be more effective than intervening training in disintegrating a habit." (p. 65).

SUMMARY AND PRESENT STATUS OF PROBLEMS

Since many phases of the general problem of retroactive inhibition have been investigated, it seems desirable at this point to enumerate the specific problems and present briefly the present status of each.

1. The existence of retroactive inhibition in recall memory. All the investigators except DeCamp have found definite indications of retroactive inhibition, i.e., poorer records after interpolated work than after interpolated rest. DeCamp used multiplication and physical work as interpolated activities with nonsense syllables as original learning. Robinson and Skaggs have clearly shown that dissimilar activities produce relatively little inhibition. Moreover, DeCamp was the only one who presented the members of the pairs of syllables simultaneously, and in most instances gave a greater number of repetitions for learning than did other investigators, except those studying the effect of the degree of learning. Skaggs, using the right associates method, found little evidence for inhibition where he gave 15 repetitions. These differences in method may partially

account for the differences in results. Individual differences may also be an important factor.

In the case of recall memory it seems safe to conclude that there is such a factor as retroactive inhibition.

2. The existence of retroactive inhibition in recognition memory. Heine's experiments seem to show rather conclusively the absence of the influence of retroactive inhibition in recognition memory. Her work, however, has not been carefully repeated. Lund in a recent study of the degree of confidence in recognition memory found that such a factor as retroaction may be present. Dahl used the recognition method in a study of the effect of sleep upon memory and found that there was some loss during both waking and sleeping intervals. Although he does not choose to explain the results by retroactive inhibition, the fact remains that the interpolated interval did decrease the retention. More experimental evidence is clearly needed on this subject before definite conclusions can be drawn, but it seems likely that retroactive inhibition is present in recognition memory.

3. Factors influencing the degree of retroactive inhibition:

a. Temporal position of interpolation. On this question there is much disagreement. Müller and Pilzecker, on the basis of the results of one experiment, concluded that memory was less affected if rest followed immediately than if work followed immediately after learning. DeCamp's results are doubtful. Robinson's results led him to conclude that the degree of inhibition is independent of the temporal position of the interpolated activity. Skaggs' results support those of Müller and Pilzecker in general, although not conclusively. Whitely's data still further complicate the question: loss was greatest when the interpolated activity came just before recall, least when it followed immediately after learning (just the opposite of the Müller-Pilzecker data) and slightly greater than this when the interpolation immediately preceded learning, a condition which had not been studied before.

b. Similarity of the original

and interpolated activities. Müller and Pilzecker here again drew a general conclusion on the basis of the results of one experiment, stating that the degree of inhibition was independent of this relationship between the original and interpolated activities. Robinson investigated the problem more thoroughly and concluded that the degree of retroactive inhibition present in a given situation was a function of the similarity between interpolated activity and original learning, although "where, on the face of things, interpolation and original learning are comparatively dissimilar there may still be an appreciable degree of retroactive inhibition" (20, p. 52). Skaggs' results were very similar to Robinson's. He concluded that the degree of similarity between original and interpolated activities is an important factor in determining the amount of retroactive effect. Whitely's results also show that the arousal of the congruous apperceptive system has a greater inhibitive influence than that of the non-congruous. Lund's results may also be interpreted to support this conclusion.

Robinson's more recent study, in which he

used measurable degrees of similarity secured by varying the number of identical consonants in original learning and interpolation, shows that the degree of interference varies inversely as the degree of similarity, or probably better stated, as the degree of identity. Robinson avoided the difficulty of ranking processes on the similarity-dissimilarity scale, but it seems that he did not touch upon the problem involved in the factor formerly designated as "similarity." His most dissimilar materials in this experiment were those which had before been described as similar, and the results bear out the former findings so far as they go. The writer has shown in a recent study that when digits are introduced into the series of consonants as used by Robinson the relationship formerly hypothecated by Robinson and Skaggs is true at least in part. Retention of four consonants was better when these consonants were followed immediately by four digits than when they were followed by four other consonants or by a mixed series of digits and consonants.

A comparison of Brockbank's and Webb's results with animals indicates that the factor of similarity is also important in animal learning. Brockbank used an interpolated activity which was dissimilar to the original problem and found no inhibition, while Webb used an interpolated activity which was similar to the original problem and found indications of inhibition.

The point seems fairly well established that the degree of retroaction varies with the degree of similarity between original learning and interpolation.

c. Degree of learning. Heine, Robinson, and McGeoch have investigated this factor. Heine, using two degrees of learning, reported a lesser degree of inhibition for the strongly impressed associations, while Robinson with a series of four comparisons found no general tendency either way. McGeoch's results favor Heine's conclusions. He used five degrees of learning and found some inhibition with all degrees, but less with the better learned series.

d. Practice. Apparently contradictory results have been obtained on this problem by

Robinson and Skaggs. Robinson found less inhibition with a practiced chess player than with subjects who did not play chess. Skaggs, on the other hand, compared the records of subjects on the first and last five of 20 trials on the reconstruction test. This comparison showed no effect of practice. However, it seems to the writer that 20 trials in the reconstruction test is too different from long practice in playing chess to be classed in the same category of practice. Skaggs' comparison of the results of the first and the last half of a series of 12 experiments with sense words shows a slight increase of inhibition.

e. Conditions of learning. Tolman found less inhibition under what he classed as "more stimulating" conditions than under his "less stimulating" conditions. Skaggs failed to substantiate these results so far as fatigue (measured by morning and evening conditions) was concerned, finding that if learning was as good in the evening as in the morning, the work interval was no more detrimental than the rest interval.

f. Length of series. Robinson's

results on this question stand unquestioned: There is a decreasing susceptibility to retroaction as the material (number lists and nonsense syllable lists) increases in length. Although there is good evidence of a lower limit to this law, as yet no work has been done to decide where this may lie.

g. Individual variation. Two men have mentioned this factor. DeCamp concluded that different subjects showed no marked individual differences with respect to the manifestation of the effect of retroactive inhibition. On the other hand, Webb's results led him to conclude that the degree of retroaction was a function of the individual. Although others writers have not commented on this factor, a study of their results indicates that this factor is an important one in any study of retroactive inhibition.

h. Age. That retroaction is a factor in adult learning has been clearly indicated by many experiments. Hinrich has also shown it to be equally effective with children from eight to 13 years in age. Whitely's comparison between records

of grammar and high school children and college students shows that retroactive effects are important with all these groups. It seems safe to conclude from these data that this factor is not a function of the age of the subject.

i. Sleep. Jenkins and Dallenbach have shown that with the two subjects whom they used recall was much better after intervals of one, two, four, and eight hours of sleep than after equal intervals of waking. Dahl found that this was true of recognition memory only for the six and eight hour intervals. After one and two hour intervals of waking, his 12 subjects made better records than after equal intervals of sleep.

j. Hypnosis. Jenkins and Dallenbach found that one subject's memory was practically unaffected after two, four, eight, and 24 hour intervals when he was hypnotised during the learning and recall periods. This finding was in agreement with the earlier work of Wienholt (reported by Moll), but in disagreement with results ob-

tained by Beaumis and Dessoir (also reported by Moll).

k. Difficulty of the interpolation. Webb suggested that the degree of inhibition was the function of the relative difficulty of the interpolation, the less difficult the interpolation, the greater the retroactive effects. The writer, in her report of the problem of similarity, has suggested that the results may indicate the influence of a difficulty factor. The indications in this case, however, are opposite from those of Skaggs, i.e., it appears that the less difficult the interpolation the less the interference.

l. The relative susceptibility of rats and humans to retroactive inhibition. Webb's conclusion that human subjects are more susceptible to retroactive inhibition than rats stands unquestioned thus far.

m. Forward reference vs. retroactive inhibition. Hunter and Yarborough obtained results with rats which indicated that there is interference of the first habit in the formation of the second rather than a retroactive influence so far as

their work with auditory-motor habits was concerned.

THEORIES OF RETROACTIVE INHIBITION

Two general theories have been proposed to explain the phenomenon of retroactive inhibition: the perseveration theory of Müller and Pilzecker and the transfer theory, which was proposed by DeCamp and qualified by Webb and Robinson.

Müller and Pilzecker based their theory upon the belief that the processes underlying retroactive inhibition and perseveration were the same. Memorizing is followed by a period of gradually diminishing activity of the neural elements involved in the memorizing. Any mental activity immediately following memorizing interferes with this so-called "setting-in" process. Since the neural activity diminishes gradually, the deleterious effect of the work would vary inversely as the time elapsing between the end of memorizing and the beginning of work.

The validity of this theory is based upon the influence of the factor of temporal position, which, as has been shown, is still under dispute.

DeCamp's transfer theory is also based upon the setting-in process. However, according to his theory, the emphasis is placed upon the identity of the neurological groups operating in learning and interpolation, the amount of inhibition varying "directly as the relative identity of the neurological groups involved" (2, p. 62).

The difficulty with this is that it does not take account of the fact that a degree of identity must be reached where reinforcement or repetition occurs.

Webb suggested a transfer theory without reference to a setting-in process. Certain elements in the original learning process may become transferred from the pattern of the original learning to the pattern of the interpolation, so that the recall of the original may be interfered with. Again there may be a transfer of elements from interpolation to recall, which would show deleterious effects.

Robinson considers these theories too limited. He says, "There is no need for so limiting

one's conceptions of similarity and transfer.....
The transfer causing retroaction, for instance, may in one case be a transfer from memorizing to interpolation and in another a transfer from interpolation to recall. All that one need assume, in order to explain any retroaction in terms of transfer, is that the situations, memorizing, interpolation, and recall, have enough in common, through content, form, process, or even temporal contiguity, to insure the reinstatement of a part of one of the situations in intimate connection with another" (13, pp. 56-57).

THE EXPERIMENTS

Statement of the Problem. We now turn to a consideration of our own experiment work* which deals with the effect of interpolated emotional reactions upon the retention of previously learned materials. Although no work has been done which bears directly upon this phase of the problem of retroactive inhibition, reference has been made by several writers to a phenomenon called retrograde amnesia. This term has been used by psychiatrists and refers to the fact that a physical shock or emotional disturbance sometimes seems to blot out the possibility of recall of events just preceding the shock. Thus Skaggs speaks of such a condition as opposed to normal conditions where the interpolation of vigorous mental work with or without emotional aspects seems to interfere with associations previously set up. Skaggs considers both as retroactive inhibition. Robinson also mentions retrograde amnesia as a pathological instance of

*Carried out under the direction of Walter S. Hunter during the years 1925-1926 and 1928-1929.

positively accelerated forgetting, and says that he does not feel in a position to say how his theory of transfer can be used profitably therewith.

Perhaps the few experiments in which Robinson gave as interpolated activity the study of pictures of nudes corresponds more closely to the present study than any other that has been reported. Robinson's purpose was to furnish an activity with some affective tone. Landis (11) (12), in his studies of emotional expression, used similar stimuli to arouse emotional reactions. Whether or not we describe the reactions to such stimuli as emotional, it is probably true that the interpolation of such an activity introduces a factor not found in ordinary reading or in the learning of numbers or syllables.

The term emotional reaction will be used in this paper to refer to a general bodily disturbance. The stimuli used to arouse such emotional reactions in the experimental situations were, of course, not so violent as those which produce the retrograde amnesia of the psychiatrists.

General Plan of Experiments. The general experimental plan used in all the problems in this study was that followed by the former investigators in the general field of retroactive inhibition: comparison was made between the results of two tests, one in which the rest or control period followed the learning, the other in which the emotional stimuli were given between learning and recall. The latter corresponded to the so-called "work" period, which will be referred to in this paper as the test situation.

The comparison of results obtained from the two tests may be made (1) in terms of percentage loss where the recall is measured before and after interpolation, or (2) it may be made in terms of recall under control and test conditions when the record of recall is taken only after interpolation. In the first case the experimental plan is as follows:

Control Situation	Test Situation
Study	Study
Recall	Recall
Interpolated Rest	Interpolated Work
Recall	Recall

In the second case the procedure would follow this outline:

Control Situation	Test Situation
Study	Study
Interpolated Rest	Interpolated Work
Recall	Recall

Both methods were used in the following experimental work.

Preliminary Experiments

Two experiments were carried out by the writer in 1926. These will be briefly reported here as preliminary studies.

Experiment I.

The Problem. The problem of this experiment was to determine the influence upon the retention of naive subjects of the reaction to strong odors (ammonia and ammonium bisulphide).

The Method and Materials. The recall method was employed and comparison was made between records of recall taken before and after interpolation. The experimental plan was as follows:

Control Situation	Test Situation
Study syllables	Study syllables
Recall	Recall
Read for three minutes	Identify odors for three minutes
Recall	Recall

The material for original learning consisted of lists of 15 nonsense syllables. These were presented on a series of 15 cards, 5½x9 inches, hinged together at the bottom. The subject was seated across the table from the experimenter who exposed the syllables one at a time by turning the cards. The time of exposure of each syllable was approximately two seconds, and from 35 to 40 seconds were required for the series.

For original learning the syllables were exposed five times, with written recall after each exposure and again after interpolation. The record of the last recall before interpolation was used as the basis for computing the loss during the interpolated intervals. The other recalls before interpolation were considered as trials in the learning process.

The subject was instructed orally to study each syllable as it was shown and to reproduce in

writing as many of the syllables as possible after each exposure.

The Interpolated Activities. The interpolated period was three minutes in length. During the control interval the subject read aloud from Webb's "History of Philosophy." During the interpolated interval of the test situation the subject was given a group of nine bottles containing odorous liquids, all of which were agreeable but two, ammonia and ammonium bisulphide. These were numbers seven and nine in the series and served as the disturbing stimuli in the experiment. The subject was instructed to sniff at each bottle and, if he knew what the odor was, to mention the name. He was told not to take time to identify those of which he was uncertain. The reaction was much the same in all cases. The odors in the first six bottles were jasmine, geranium, nutmeg, orange, caraway, and cassia, all rather weak. By the time the seventh bottle was reached the subject was sniffing closely and carefully. The reaction was a sudden start and a quick sidewise movement of the head. The reaction to the

ammonium bisulphide in the ninth bottle was not so marked, perhaps partly because the odor itself is not so violent, and partly because the subject was rather suspicious as a result of his experience with the ammonia.

The Subjects. Twelve subjects served in Experiment I. They were men from the elementary psychology class, all of whom were freshmen but two, who were juniors. None had had any former experience in the laboratory, and none knew the nature or the purpose of the experiment. Each came at a stated hour to go through the control situation and was asked to return at the same hour one week later, when he was given the test situation.

The Results. The results of this experiment are presented in Table 1, which shows the percentage loss for the individuals and for the group in the control and test situations. The averages indicate an approximately equal loss under both the control and test situations. Individual records vary greatly in the percentage of loss under each condition,

Table 1. Percentage of Loss in the Control and Test Situations.

Subject	Percentage Loss	
	Control	Test
1	36.3	45.4
2	0.0	0.0
3	0.0	0.0
4	25.0	33.3
5	0.0	0.0
6	0.0	9.0
7	0.0	0.0
8	18.1	8.3
9	0.0	14.3
10	50.0	11.1
11	0.0	45.4
12	25.0	7.0
Ave. Percentage Loss	12.8	13.7
M. V.	4.2	3.7

from 0 to 50%. Of the individual records, five show no loss for either the control or the test interval, four show more loss after the test interval, while three show more loss after the control interval.

The Conclusion. Under the conditions described in this experiment, we must conclude that the reactions to the unexpected stimulus of strong odors does not bring about a greater loss of retention than

does reading aloud.

Experiment II.

The Problem. This experiment was designed to determine the effect of a complex disturbing stimulus upon retention. This stimulus involved the sudden loss of bodily support, the crash of falling weights, and a brilliant flash of light.

The Method, Materials, and Instructions. The recall method was used as in the preceding experiment and the general experimental plan was the same. The series of 15 nonsense syllables were exposed six times, but written recall was taken only after the sixth and again after interpolation instead of after each exposure as before. The instructions to the subject were the same as those in Experiment I except that he was not asked for the additional recalls.

The Interpolated Activities. During the interpolated interval of the control situation the subject was asked to read silently from W. S. Franklin's "Bill's School and Mine" for three minutes.

The emotional stimulus employed in the inter-

polated interval of the test situation was the sudden loss of support, caused by the falling of the back of the chair, together with the reaction caused by a light flash produced by the explosion of an Eastman flash cartridge, and the noise produced by falling weights. The apparatus and procedure were as follows: The subject was seated in his usual chair, a Morris chair, and instructed to lean back, close his eyes and relax, while he repeated the alphabet as rapidly as possible. (Subject H read instead.) The back of the chair was held in position by a rod which lay in grooves on the backward entensions of the arms. A wire was fastened around this rod, passed up over a horizontal round in the back of the chair, and fastened at the other end to a weight, which lay upon a small platform screwed on the backward extension of the arm. A string was tied on the weight and passed across a table to the opposite side of the room. By pulling the weights off the chair arm by the string, the experimenter could cause the chair-back to fall. The wire connecting the rod and the weights was of sufficient length to allow the

weights to strike the floor, thus producing a considerable crash. While the string was pulled with the right hand, the fuse of the flash cartridge was lit with the left by means of a candle which stood back of a screen. The cartridge was placed on a shelf to the side of the subject because of the danger of injury to the eyes produced by such an intense and sudden flash if it should be in direct vision.

The Subjects. Eleven men from the elementary psychology class served as subjects in this study. Five of these had served in Experiment I approximately three weeks before. The others had had no previous experience in the laboratory. The new subjects knew nothing of the nature or purpose of the experiment. The five who had served in the former experiment knew nothing of the nature of the interpolated disturbance.

The Results. The results obtained are presented in Table 2. The averages of the percentage loss in the control and test situations are very nearly the same, 15.9% for the control situation and 17.8% for the test situation. In view of the fact that

the M. V. is 5.4% in each case, the difference is negligible. A study of the individual records shows that two subjects show no loss in either the control or the test situation, one shows the same loss in both, three show more loss in the control situation, and five show more in the test situation.

Table 2. Percentage of Loss in the Control and Test Situations.

Subject	Percentage Loss	
	Control	Test
1	0.0	10.0
2	0.0	0.0
3	0.0	0.0
4	8.3	16.6
5	18.1	25.0
6	15.4	7.7
7	60.0	60.0
8	6.6	27.3
9	33.3	15.4
10	22.2	25.0
11	11.1	9.0
Average percentage Loss	15.9	17.8
M. V.	5.4	5.4

Although the results show no more influence of retroactive inhibition than do those of the former experiment, the reaction to the disturbing stimuli

was more pronounced in all cases. In two cases quite decided reactions occurred: When the flashlight cartridge exploded in the test with Subject 7 the card-board screen caught on fire. The experimenter, in attempting to remove the flaming card, accidentally passed it in front of the electric fan, and dropped it on the floor as the flames increased. The subject was called upon to put the fire out. Not more than the three minutes was taken in this procedure. The effect of this on the subject's total correct recalls was not greater than the three minutes interpolated reading.

In the test with Subject 10 the experimenter burned her hand on a tin screen, which was heated by the flash, and was also momentarily blinded by the flash. The two stimuli were sufficient to call forth an exclamation, which caused the subject to think that something serious had happened. He jumped up from his chair (after catching himself as the back of the chair fell) and came around the table. When the experimenter explained that everything was all right, and asked him to go back and write the syllables again, he said,

"Oh, I can't remember one of them now." His record in Table 2, however, shows that the loss was but very slightly greater than for the reading period.

The Conclusion. The complex stimulus used in the test situation of this experiment failed to produce a more significant loss of retention than that which occurred during the control situation.

Conclusions from the Results of the Preliminary Experiments. The results of Experiment I and II indicate that the disturbing stimuli employed therein do not effect the retention of nonsense syllables as measured by the recall method more than does the reading of ordinary prose.

A Note on the Reliability of the Method Used in the Preliminary Experiments. In order to evaluate the results of the two preliminary experiments with respect to the method by which they were obtained, the reliability of the method was computed. A reliability coefficient of .84±.025 was obtained by the retest method with a group of 52 elementary history students. The interval between tests was 84 days.

The same series of 15 nonsense syllables was used in each test and conditions and instructions were the same. Presentation was visual and was made in the manner described above for individual subjects. Since the coefficient is relatively very high, we may assume that the results possess a fair degree of reliability.

The Main Experiments

The work described in this section of the paper was done in the academic year 1928-1929. The purpose and general plan of the experiments were the same as those of the preliminary experiments, but several changes were made in the apparatus and procedure. These changes will be described in connection with the individual experiments.

Experiment III.

The Purpose. The purpose of Experiment III was to determine the effects of five interpolated activities upon retention when the subjects were acquainted with the general nature of the experiment. The activities will be described specifically later, but may be

indicated by descriptive title here: (1) reading silently with lip movement (control activity); (2) reading aloud from a humorous selection, (3) reading with noise and flash, (4) reading with electrical shock, and (5) reading silently with shock or threatened shock, loss of bodily support, and noise.

The General Set-Up. As in the preliminary experiments, the subject was seated across the table from the experimenter and in front of the exposure apparatus which for Experiments III, IV, and V was the Spindler-Hoyer apparatus. The Morris chair which was described in the earlier experiments was used again, but was somewhat changed as explained below. At the experimenter's left, between her and the subject, was a board screen which allowed the experimenter to manipulate records and apparatus without disturbing the subject. On the right side of the exposure apparatus was a table lamp so shaded as to light only a small area at the exposure window. At the subject's left was a floor lamp which the experimenter could manipulate. When the subject was reading this was turned on and

furnished illumination at the proper angle for reading when the subject sat back comfortably in the chair. This light was turned off when the subject was studying the learning materials.

The Learning Materials. Three types of material were used for original learning: nonsense syllables, three-place numbers, and three-letter words. Twelve syllables comprised a list, while 10 numbers or 10 words made up lists of those materials. The syllables were chosen from the lists of syllables which Glaze (5) found to have 50% or less association value. Words were taken from Cason's (2) list, while the numbers were constructed at random except that in no case did the digits appear in regular ascending or descending order, nor did arrangements such as 2, 4, 6, or 3, 6, 9, or vice versa, occur. At any one experimental session a subject learned one list of each type of material.

The Method. The recall method was employed. Exposure was made visually by means of the Spindler-Hoyer apparatus which was operated with a weight and

not by electricity. Nonsense syllable lists were shown six times, with an exposure time of two seconds for each syllable in any one exposure and an interval of 14 seconds between each two of the six presentations. For the number and word lists the exposure time for each member of the lists was the same as that for the syllables, but the interval between presentations was 18 seconds in length. The number series were shown five times; the word series, twice. Recall was requested only after interpolation, the experimental plan being as follows:

Control Situation	Test Situation
Study	Study
Read for two minutes	Read with disturbance for two minutes
Recall	Recall

Preliminary Practice. Each subject had preliminary practice periods weekly at his regularly appointed hour for two weeks before the experiment proper began. At these sittings each individual studied one list of each type of material, i.e., nonsense syllables, numbers, and words. The interpolated

interval in each case was occupied with reading silently with lip movement.

Instructions and Procedure. When the subject came into the experimental room he was seated in the chair across the table from the experimenter. The reading light was turned on, and he was then asked to read the following instructions which always lay on the table beside the apparatus.

"INSTRUCTIONS

"In general: For the best interests of this work I request that you mention this experiment to no one--and we shall not discuss it in here.

.....

You will be shown a list of nonsense syllables, words, or three-place numbers. Study each member of the list and pronounce it aloud as it is exposed for I shall ask for a written recall later. Words will be shown twice; numbers, five times; and nonsense syllables, six times.

After the last exposure of whichever list we are working with, I shall give you some reading

material from which I wish you to read with lip movement until I ask you to stop.

"Immediately after the stop signal on the reading you are to write as much as you can (regardless of order) of the list studied. Do not begin to write until I have given the 'Ready, write' signal and please say 'Now' when you have finished, for I shall time you on this recall."

The reading light was then switched off and the subject was told what material would be shown first and what the number of exposures would be. The material was exposed the prescribed number of times. After the last exposure the machine was stopped, the reading lamp was turned on, and the subject was put through one of the five interpolated activities. This procedure was repeated with a list of each of the other two materials at each sitting.

The Records. Recall records were taken only after interpolation. Comparison was therefore made between recall after the different interpolated activities rather than between recall before and after interpolation.

Time was recorded from the time the experimenter said "Ready, write" until the subject said "Now." This was taken by means of a stop watch.

In scoring, one point was given for each syllable, word, or number correct in kind. One half credit was given for two letters or digits correct.

The Subjects. Ten subjects served in this experiment. One was a senior in Clark College who had served in the preliminary problems in 1926. He therefore knew the general nature of the experiment. The other subjects were graduate students in the Department of Psychology. Six of these had heard the preliminary problems reported in class. The other three were informed that the purpose of the experiment was to study the effects of emotional reactions upon retention, but they were given no information as to the exact situations to which they would be subjected. Each subject served five times, and after the first time of course knew more or less what could be expected, although he never knew what situation was to be interpolated at any given time.

At the beginning of the experiment the subjects were requested not to talk about the work outside the experimental room. However, the experimenter soon realized that the shock situation was particularly disturbing and that a few chance remarks of the subjects were tending to increase this disturbing effect. Thereafter outside discussion was encouraged. All subjects became very strongly negatively conditioned to the whole situation.

The Interpolated Activities. As stated above, five situations were used as interpolation. The length of the interpolated interval was two minutes in all cases.

(1) Reading. This situation corresponded to the usual rest period and was the control situation in this experiment. The material was always the same during the experiment proper and was the first page of the chapter on "Sweden" in Wood's "The Influence of Monarchs."

(2) Reading aloud from a humorous selection. For this activity the subject was handed a typewritten

copy of "The Heedless Horseman" by Weare Holbroke or "The Garter" by Dorothy Parker and was asked to read aloud until the experimenter said "Stop!" No subject ever read the same selection from these articles more than once.

(3) Reading with noise. Immediately after the learning period, the subject was handed the book and began to read. A revolver was fired under the table just as soon as the experimenter could do so after handing the book to the subject. In some of the experiments a flash lamp was set off back of the experimenter and facing the subject. This was not used in all of these situations because of the excessive amount of smoke which it produced in the small experimental room. When a naive subject from the group which served in Experiment IV was coming immediately after a subject of Experiment III, it seemed unwise to use the flash lamp. At the end of the two minute period the revolver was again fired, and in some cases another shot occurred at the end of the first minute of interpolation.

(4) Reading with shock. In this case before the subject was given the book, leather wristlets were placed on his wrists. In these wristlets copper strips were woven which were connected with the electric lighting system through a rheostat and a switch. The connecting wires were long enough to allow the subject perfect freedom of movement. By means of the rheostat and switch the experimenter could control the intensity and frequency of the shocks.

The shocks were given at approximately 30 second intervals, beginning as soon as the subject started to read. A constant intensity of about 70 volts was used throughout this experiment.

(5) Reading with noise, loss of bodily support, and shock or threatened shock. The subject was seated in the Morris chair as in all the experiments. The seat of this chair was hinged at the front as well as at the back. The seat was held in position by a support which the experimenter could cause to collapse by pulling a small rope. This allowed the seat to drop 10 inches at the back. By the same pull of the string

which collapsed the support under the chair, the rod supporting the back of the chair was pulled up, allowing the chair-back to fall simultaneously with the fall of the seat. The rod connecting the ends of the backward extensions of the arms prevented the chair-back from falling to the floor.

The wristlets used in Activity (4) were attached in this situation also, and the current was turned on two or three times for most of the subjects. However, if the subject had been shocked before during the day's program, the mere presence of the wristlets seemed disturbing enough to some individuals and the current was not switched on.

Program of the Situations. As stated above, each subject learned three lists of material at each experimental session. After the study of each list he engaged in one of the five activities just described. Since five sessions were thus necessary in order to have a record of recall for each type of material after each interpolated situation, some precaution had to be taken to equalize possible practice effects. To

accomplish this a program was drawn up as follows:

Group	Materials	Days I	II	III	IV	V
A	Syllables	(1)	(4)	(2)	(5)	(3)
	Numbers	(2)	(5)	(3)	(1)	(4)
	Words	(3)	(1)	(4)	(2)	(5)
B	Syllables	(2)	(5)	(3)	(1)	(4)
	Numbers	(3)	(1)	(4)	(2)	(5)
	Words	(4)	(2)	(5)	(3)	(1)
C	Syllables	(3)	(1)	(4)	(2)	(5)
	Numbers	(4)	(2)	(5)	(3)	(1)
	Words	(5)	(3)	(1)	(4)	(2)
D	Syllables	(4)	(2)	(5)	(3)	(1)
	Numbers	(5)	(3)	(1)	(4)	(2)
	Words	(1)	(4)	(2)	(5)	(3)
E	Syllables	(5)	(3)	(1)	(4)	(2)
	Numbers	(1)	(4)	(2)	(5)	(3)
	Words	(2)	(5)	(3)	(1)	(4)

"Groups" here represent but two persons. "Days" refer to the experimental days which were planned to be one week apart, but which were in two cases as far as three weeks apart, and in four cases two weeks apart. Arabic numbers in parentheses refer to the interpolated activity used after the studying of the type of material indicated in the second column. This arrangement equalized practice factors in relation to materials and

situations.

It was not found possible to follow this arrangement precisely. The most outstanding exception was the substitution of Activity (2) for Activity (5) in three cases in the early part of the work, which necessarily brought a number of (5)'s to the last session.

The order of presentation of lists was varied in an irregular manner. Usually if a control activity (Activity 1) was called for on the day's schedule, the list of material which it was to follow was given first. On the other hand, usually when Activity (5) was called for, it came last because of the necessity for rearranging the chair after utilizing that situation. This was not always the case, for it seemed undesirable to allow any subject to get cues as to what would happen and it seemed that he might learn to suspect that the first situation on any given day would be Activity (1), and the last, (5).

Descriptions of Reactions. Activity (1). The reaction of all subjects to Activity (1) was normal. After studying the material which was to be learned,

they were told that the interpolated period was to be a "rest" period, i.e., that nothing would happen while they read. Subject 3 did not believe this statement the first time it was made to her, hence the anticipation of one of the other activities may possibly have furnished a distraction during her control period.

Activity (2). This situation was not successful in bringing out the laugh response in all cases, although it was very successful with some subjects. If the subject showed any inclination to laugh , the experimenter laughed very freely. All subjects at least smiled.

Activity (3). All the subjects started more or less at the revolver report in this situation. Extra loud blanks were used, and since the room was small, the report was quite deafening. The smoke was also a disturbing factor and nearly all the subjects remarked about its disagreeableness.

Activity (4). The electric shock was by far the most disturbing stimulus. The strength of the current was sufficient to draw the arms up with considerable force. The subjects often exclaimed.

Practically all of them took the precaution to wipe their hands dry before the wristlets were put in place, but all perspired rather freely; the hands of Subjects 5 and 6 were always wet when the wristlets were removed. Individual reactions will be described in connection with the results.

Activity (5). Here the reaction to the shock was the same as that described above. The reaction to the noise and fall was not particularly marked. Subject 2 reported a decided feeling of relief in one case when the chair collapsed because she then knew from former experiences that there would be no more shocks in that particular interval.

The Results. Comparisons may now be made between the results obtained under the control and test situations on three bases: (1) recall records, (2) total time records, and (3) recall time per syllable.

The recall data for the three types of material are presented in Tables 3, 4, and 5 where are shown the individual and average percentages of correct recall under each of the five situations. The records

Table 3. Percentage of Correct Recall of Nonsense Syllables.

Subject	Activity					
	(1)	(2)	(3)	(4)	(5)	(2-5)
1	58	25	50	25	25	31
2	67	92	100	92	100	96
3	50	58	75	42	42	52
4	71	54	67	100	100	80
5	42	13	42	13	13	20
6	58	42	33	58	70	51
7	75	50	58	33	75	54
8	58	42	38	42	--	41
9	42	38	25	45	38	37
10	50	45	50	33	63	48
Average	57	46	54	48	58	51

of the percentage of correct recall for the test situations, i.e., those tests in which Activities (2), (3), (4), and (5) were interpolated, are also presented for each type of material in Column 7 of each table.

An examination of these data shows that out of 39 comparisons between recall after control and test activities, there are only 11 records which show superior recall for the test situations where the nonsense syllables were used. For this material the difference between the averages of

Table 4. Percentage of Correct Recall of Numbers.

Subject	Activity					
	(1)	(2)	(3)	(4)	(5)	(2-5)
1	35	20	35	35	30	30
2	70	75	45	65	75	65
3	80	50	75	55	65	61
4	90	70	90	90	100	88
5	50	75	45	60	85	66
6	40	25	25	25	30	26
7	40	30	35	45	60	43
8	45	--	50	30	60	47
9	55	40	20	0	30	30
10	30	60	60	65	60	61
Average	53	49	48	47	60	52

Column 2 and Column 7, i.e., between the control and the test situations, is 6% with a P. E. of 3.4, which is a rather insignificant difference. However, it will be noted that the average recall following Activities (2) and (4) was considerably poorer than that following the control activity.

In Tables 4 and 5 we find that out of 39 test records for the numbers and words there are 15 and 14 records respectively in which the better records were made after the test situations. The averages of recall under the test situations with numbers is 52% as compared with 53% under the control situation,

Table 5. Percentage of Correct Recall of Words.

Subject	Activity					
	(1)	(2)	(3)	(4)	(5)	(2-5)
1	80	50	50	70	70	60
2	70	80	80	60	70	73
3	90	90	75	90	80	84
4	90	80	100	100	80	90
5	90	90	90	90	90	90
6	60	50	70	90	65	69
7	80	80	90	60	60	73
8	60	30	60	70	00	53
9	50	50	50	60	20	45
10	70	60	90	80	60	73
Average	74	66	76	77	66	71

yielding a difference of 1% with a P. E. of 4.7. The same figures for words are 74% for the control situation and 71% for the test situations; the difference is 3%±4.0. The average recall of the numbers is practically the same under Situations (2), (3), and (4), and these averages are slightly lower than that of the control situation. For Situation (5), however, there is a very high average, 60%, which is considerably higher than the average for the control situation. The recall records for the words likewise show rather great differences between the various situations. Under Situations (2) and (5) the recall was as much as

10 and 11% poorer than those made in Situations (3) and (4), which are superior to the control record by 2 and 3%, respectively. None of these differences meet the requirement for reliability, i.e., none of them are four times the P. E.

We may now turn to a consideration of the time records. Tables 6, 7, and 8 present the total time records in seconds. An analysis of the nonsense syllable data shows that out of 39 individual test records 13 show recall time equal to, or greater than, that for the corresponding control tests. For the numbers and words these numbers are 15 and 11, respectively. The average total time for the group in the test situations is less than that required for the control test in only two out of 12 cases. The average time for the recall of nonsense syllables after the four test activities is 60 seconds as compared with 49 seconds after the control activity. The corresponding figures in the case of the numbers is 40 and 41 seconds; and in the case of the words, 43 and 34 seconds for the test and control situations, respec-

tively. The records of recall time for numbers then are the only ones which do not show that a greater length of time was required for recall under the test situations. In some individual situations the average

Table 6. Total Recall Time for Nonsense Syllables. (Seconds)

Subject	Activity					
	(1)	(2)	(3)	(4)	(5)	(2-5)
1	27	38	22	30	30	30
2	103	125	60	125	150	115
3	69	49	115	210	120	124
4	48	54	59	54	60	58
5	38	25	22	25	17	22
6	24	38	26	25	32	30
7	60	114	62	112	120	102
8	40	55	66	51	--	57
9	60	53	42	53	38	47
10	25	20	16	15	20	18
Average	49	57	49	70	65	60
M. V.	18.6	25	23	47	44	35

time differences are rather striking. For instance, the tests with nonsense syllables following Activities (4) and (5) required 70 and 65 seconds, respectively, as compared with the average of 49 seconds in the control situation. In view of the large M. V.'s, however,

Table 7. Total Recall Time for Numbers in Seconds.

Subject	Activity					
	(1)	(2)	(3)	(4)	(5)	(2-5)
1	26	17	15	29	15	19
2	84	100	81	60	83	81
3	64	73	45	47	68	58
4	70	42	32	37	53	41
5	20	28	36	25	32	30
6	12	19	16	15	35	21
7	35	48	40	40	50	45
8	45	--	44	45	60	50
9	43	40	43	25	43	38
10	12	16	12	22	32	21
Average	41	42	36	35	47	40
M. V.	19	19	14	11	16	13

we are not justified in considering any of these differences significant. They are suggestive, nevertheless.

An examination of the M. V.'s in Table 6 shows that the variability of the recall time is considerably greater in the test situations that in the control situations. This fact is true only of the tests with nonsense syllables.

Another method of considering the time records is shown in Tables 9, 10, and 11, where are

Table 8. Total Recall Time for Words . (Seconds)

Subject	Activity					
	(1)	(2)	(3)	(4)	(5)	(2-5)
1	16	15	37	23	19	24
2	50	84	88	85	67	81
3	50	45	50	37	70	51
4	25	35	25	20	35	29
5	27	33	28	40	27	32
6	22	32	20	40	57	37
7	57	85	48	74	74	70
8	42	34	35	40	--	36
9	40	60	35	42	30	42
10	11	40	20	17	21	25
Average	34	46	39	42	44	43
M. V.	14	18	15	13	20	17

presented the times required per each syllable, number, and word correctly reproduced. Again we have 39 records taken under the test situations and here we find for nonsense syllables, numbers, and words, respectively, that in 30, 22, and 30 records the recall time per syllable in the test situations is equal to or greater than that in the corresponding control situations. These figures offer more consistent evidence of interference in the test situations than does either the recall or the total time record.

Table 9. Recall Time for Each Nonsense Syllable Correctly Reproduced.

Subject	Activity					
	(1)	(2)	(3)	(4)	(5)	(2-5)
1	4	10	4	8	8	8
2	11	11	5	11	13	10
3	11	7	14	42	14	20
4	6	8	6	6	5	6
5	7	13	4	13	9	10
6	3	8	7	3	3	5
7	5	19	9	28	15	18
8	6	11	12	11	--	11
9	12	12	14	10	8	11
10	4	4	3	4	3	4
Average	7	10	8	14	9	10

Table 10. Recall Time for Each Number Correctly Reproduced.

Subject	Activity					
	(1)	(2)	(3)	(4)	(5)	(2-5)
1	8	8	4	8	5	6
2	12	13	18	9	11	13
3	8	15	6	9	11	10
4	8	6	4	4	5	5
5	4	4	8	4	4	5
6	3	8	6	6	12	8
7	12	16	11	9	8	11
8	10	-	9	15	10	11
9	8	10	21	3	14	15
10	4	3	2		5	4
Average	8	9	9	8	9	9

Table 11. Recall Time for Each Word Correctly Reproduced.

Subject	Activity					
	(1)	(2)	(3)	(4)	(5)	(2-5)
1	2	3	7	3	3	4
2	7	10	11	16	10	12
3	6	5	7	4	9	6
4	3	4	3	2	4	3
5	3	4	3	4	3	4
6	4	6	3	3	9	5
7	7	11	5	12	12	10
8	7	11	6	6	-	6
9	8	12	7	7	15	10
10	2	7	2	2	4	4
Average	5	7	5	6	7	6

Averages are greater for the test situations in all cases except that following Activity (4) in the number test and that following Activity (3) in the word test. In both these situations the averages are equal for the control and test situations.

It may be interesting to examine a few individual records in cases where there were particularly striking reactions to the disturbing stimuli. Subject 9 had a great antipathy for the shock situation during the early part of the experiment. When the

wristlets were put on for the third time he acted much disturbed and said that he didn't believe he could remember a number and that it wasn't necessary to turn on any current. As a matter of fact at the end of the time he did not recall any number correctly. Subject 6 gave the same suggestion, as if to avoid the situation. He recalled 2.5 numbers in 15 seconds as compared with four in 12 seconds under the control situation. Subject 5 seemed never to be particularly disturbed by anything, but in one case the experimenter accidentally moved the switch down in pulling the string to collapse the chair and the current was left on. The subject appeared to be really frightened. He recalled only two syllables in 25 seconds as compared with five in 38 seconds in the control situation.

Conclusions. Because of the small number of subjects used in this experiment, the results must be regarded as suggestive rather than conclusive. The following suggestions may be indicated:

1. The recall records, when averaged, give negative results so far as evidence of emotional interference is concerned. However, since individual

records show that in 66% of all the test situations recall is less than or equal to that in the corresponding control tests, inhibitive effects are indicated. Individual cases where reactions were unusually marked show comparatively great loss in the recall records.

2. Total time records for recall of the nonsense syllables and words rather consistently indicate interference in the test situations. Sixty-seven per cent of the individual records indicate greater recall time in the test situations.

3. The average time taken per syllable correctly recalled very consistently indicates some interference of the test situations, as does also the average time per number and word correctly reproduced. Seventy per cent of the individual records show the influence of such interference.

Experiment IV.

The Problem. The results of Experiment III were more suggestive than conclusive and it seemed wise to continue the study with the use of a more sensitive method than the recall method and with one particular emotional situation rather than with several. Hence Experiment IV was designed to determine more accurately by means of the right associates method the effect of Situation (5) of Experiment III on a new and larger group of subjects. In the course of the experiment with the first two subjects it became evident that a more analytic timing method was desirable and the one described below was introduced.

Methods, Materials, Instructions, and Procedure. The right associates method was employed. Twelve syllables were used for each test series. These were presented serially in trochaic rhythm by means of the Spindler-Hoyer apparatus. Each item of a pair was exposed 1.5 seconds, with no interval between. There was one blank exposure between pairs, i.e., an interval of 1.5 seconds. Five presentations were given with an interval of 10 seconds between presen-

tations.

The instructions were as follows:

INSTRUCTIONS

In general: This work will furnish a part of the data for my doctor's thesis and I wish to make two very earnest requests concerning it: (1) Please do not discuss what happens here with anyone--when your classmates ask you what it's all about, etc., just say it's a problem in learning and that I asked you to say nothing more about it. (2) Please do your best to learn the syllables which I shall show you. I am not in the least interested in personal records and am certainly not interested in, or trying to test, your intelligence. I shall, in fact, treat your records by number and not by name.

.....

A series of nonsense syllables will be exposed on the exposure apparatus in front of you. Please pronounce each syllable to yourself as it appears. You will note that they are shown consecutively, but in this sort of rhythm, '' '' '', that is, two syllables will

be shown with a short interval between, then there will follow a relatively long interval, after which two more syllables will follow, etc. I wish you to learn the syllables in pairs. The list will be shown five times.

Immediately after the fifth exposure I shall give you a typewritten list of the first syllables of the pairs and ask you to write the second syllables in the appropriate places. Do not begin to write until I have said "Ready, write," and please say "Now" as soon as you have finished or are quite sure you can recall no more. Do not delay unduly, for I shall time you on this recall.

Then I shall give you a book from which I wish you to read aloud until I say "Stop." Just read, don't study--I shall not ask you to recall anything you have read.

At the stop signal I shall hand you a second list of the first syllables (arranged in different order from the first list) and again you are to write after each (or after as many of them as you can) the

appropriate second syllables. I shall give you the "Ready, write" signal as before and you will say "Now" when you have finished. (Time record taken here, too.)

Summary of the Steps in the Experiment.

1. Study syllables in pairs.
2. Write second syllables after appropriate first syllables on list. "Ready, write" signal and "Now" important here.
3. Read until stop signal is given.
4. Write second syllables after appropriate first syllables on a second list. "Ready, write" signal and "Now"--don't forget.

In addition to the written request not to discuss the experiment outside, the experimenter said to each subject as he left the room, "The important thing to me is that you do not talk about this outside." And after the second session the final statement was "Of course, it is more important than ever now that you say nothing about this."

In the preliminary practice period a list of five pairs of syllables was simply learned and recalled

with all the information given that the subject might request. He was shown the typed list of first syllables prior to the exposure and told what would be expected of him after the fifth exposure. With the second preliminary list of eight pairs instructions were followed exactly. The subject read for two minutes from "Bill's School and Mine" after the first recall. The typed list of first syllables for the second recall was in reverse order from that of the first list.

At the regular experimental session the second week the subjects were given the same sheet of instructions, but were told that the lists would have six pairs and would be shown five times. After the learning of the first list and the first recall of this list the subject read aloud again the same passage from "Bill's School and Mine" as he read in the practice session, and then was asked for the second recall.

A few minutes interval was allowed between this recall and the presentation of the second list. Immediately after the presentation of the second list

and the first recall of this the experimenter started the stop watch, then arose and went around the table, informing the subject that he would read as usual, but that there would be an added diversion: "I'll put you in the electric chair for a while." The bracelets were then put on and the book handed to the subject. This required from 30 to 45 seconds as in the former experiment. The current was switched on at 30 second intervals as before and the chair fell about seven seconds before time was called. Without stopping to remove the bracelets the experimenter asked the subject for the second recall.

Records Taken. The following records were taken in this experiment:

1. The record of recall was taken in terms of second syllables supplied on the list of first syllables. These were scored by the method suggested by Kjerstad (11) by which a possible 20 points is assigned to each syllable as follows: first letter of the syllable, five points; second letter, three points; third letter, eight points; and position, four

points.

2. A time record was kept for the recall of each syllable. This the experimenter obtained by making a time scale on a card upon which she could check the time (read from the stop-watch) as the subject completed each syllable. The paper upon which the subject wrote was always visible to the experimenter under the exposure apparatus, but the subject was not aware of that fact. This method of timing as used in this experiment is admittedly not accurate and the experimenter did not attempt to get it closer than $2\frac{1}{2}$ second intervals. Therefore all the records were given as $2\frac{1}{2}$, 5, $7\frac{1}{2}$, 10 seconds, etc.

3. A total time record was obtained as in Experiment III, recording the time from the time the experimenter said "Ready, write," until the subject said "Now."

Subjects. Twenty-nine elementary psychology students, all men, served as subjects for this work. None of them knew the problem and but one had been in the experimental room prior to the time he came for

experimentation. Only one had had any experience with nonsense syllables; he had been in the history group which took the two tests mentioned in the statement on the reliability of the recall test as used in the preliminary experiments.

Each subject was given a preliminary practice period. Appointments for half hour sessions were made in class with the understanding that each one should come at the day and hour stated for two weeks.

Description of the Reactions. With but few exceptions this group displayed the same aversion to the shock situation that was evident in the graduate group of students. Both voluntary reports and the behavior of the subjects indicated this fact. The general disturbance was in most cases quite noticeable in the character of the reading. In the majority of cases the subject read as if he were just reading words, often making mistakes which rendered the material absolutely meaningless. The voice was characteristically heightened in pitch. One subject decreased his speed

of reading, while most of the others increased it. If the shock was relatively weak some of the men continued to read, but the voice went up the scale still more than the characteristic heightening mentioned above and dropped again when the shock was ended. When the shock was stronger and the arms and the book were thrown upward, the reader stopped and often exclaimed and looked accusingly at the experimenter. Several laughed, one to such an extent that it made reading practically impossible.

The fall was in many cases thought to be accidental. It did not seem so disturbing as the shock. Only one subject reported that it was more exciting than the shock.

In five cases the current failed to stimulate the subject for various reasons. However, since the bracelets were on in every case and the fall occurred in all cases, the records of these subjects were not eliminated.

The Results. The data from the recall records are presented in Table 12. In these figures the recall

before interpolation in each control and test situation was taken as 100% and the recall after interpolation is given on this basis. The "difference" then is the difference between the average of percentage recalled after interpolation and the recall before interpolation (100%).

In the control experiment the difference is 3.72% and the chances are only 85 in 100 that the true difference is more than zero. In the test experiment the chances are 99 in 100 that the difference of 15.48% is reliable. A study of the individual records shows that nine subjects made better records after interpolation than before in the control test, while only two did so in the test situation. The high average of the control group, 103.72%, is due to the extreme score of Subject 13, a score which I cannot account for. Without this score the average is 91.17%. The difference then is 8.83%, which is a reliable difference.

The greater loss during the test experiment we must attribute to the disturbance of that situation.

Table 12. Percentage of Recall after Interpolation in Terms of Recall before Interpolation.

Subject	Control	Test
1	104.00	100.00
2	62.71	86.08
3	45.10	49.21
4	36.36	91.80
5	119.42	100.00
6	94.25	100.00
7	142.11	90.00
8	80.00	79.31
9	81.18	71.21
10	88.24	127.27
11	100.00	75.00
12	136.00	90.28
13	485.71	100.00
14	100.00	50.70
15	92.66	100.00
16	71.43	138.46
17	129.41	100.00
18	62.50	100.00
19	66.26	14.58
20	160.00	80.00
21	128.57	100.00
22	81.25	54.55
23	90.00	100.00
24	28.57	44.44
25	95.18	65.83
26	82.61	70.00
27	117.19	75.00
28	57.84	99.99
29	100.00	97.32
	103.72	84.52
Average	3.72	15.48
"Difference"	2.4	4.6
P. E.$_{diff.}$		

All other factors were constant for the two experiments. The length of the interval, the surroundings, and the reading material were identical.

The time records are presented in Table 13. These figures show the average time in seconds for the recall of each syllable written, whether it was correct or incorrect, and the average time elapsing from the experimenter's "Ready, write" to the subject's "Now." The time records for the incorrect syllables were included because the experimenter could not determine correctness or incorrectness of the syllables when this record was taken. Since N varies, it is given with each mean. Records of time for individual syllables were not taken for the first three subjects tested, hence even for Syllable 1, N is but 26, and it drops with each succeeding syllable as attempts to recall that syllable decreased.

The time required for the recall of the first two syllables seems to indicate a temporary interference of the emotional factor. The first syllable on all recalls except after the interpolated

disturbance required an average of four seconds. After that interpolation the average for the 26 individuals was eight seconds. For the recall of the second syllable 16 seconds were required after the emotional disturbance as compared with ten and 11 seconds for the other three recalls. This retardation of the recall after interpolation in the test experiment practically disappears by the time the third syllable is reached; the subject apparently works faster after the first retardation.

Conclusion. In this experiment the results obtained by the right associates method indicate that the emotional reactions affected the retention of the subjects. Evidence for such emotional interference was found in both the recall and the time records. A particularly interesting fact which was brought out in the time records was the temporary blocking and later facilitation of the recall after the disturbing interpolation.

Table 13. Average Time in Seconds for Each Syllable and Average Total Time.

	Control				Test			
	Before		After		Before		After	
Syl.	Ave.	N	Ave.	N	Ave.	N	Ave.	N
1	4	26	4	26	4	26	8	26
2	7	24	7	23	6	26	8	24
3	8	20	11	18	10	24	8	21
4	8	17	11	15	5	20	1	17
5	7	10	8	9	6	14	14	10
6	13	10	9	8	16	13	7	8
Tot.	55	29	54	29	48	29	44	29
M. V.	21		24		21		20	

Experiment V.

The Purpose. This experiment was designed to supplement Experiment IV in two ways: (1) a more accurate method of measuring the recall time for each syllable was utilized, and (2) data were collected from a larger group of subjects under conditions essentially similar to those of the former experiment.

The Method and Materials. The right associates method was used as in the preceding experiment. The plan was as follows:

Control Experiment	Test Experiment
Study syllables	Study syllables
Recall	Recall
Read for two minutes	Read for two minutes with shock and revolver report
Recall	Recall

Six pairs of syllables were used in each list and were exposed five times.

Instructions, Preliminary Practice and Procedure. The subjects who had served in Experiment IV were given the following instructions: "Instructions will be the same as in the former experiment in which

you served. They need only be summarized here:

1. Study the list of syllables which will be shown, associating the second syllable of each pair with the first syllable of that pair.

2. Fill in the second syllables of the pairs on the list of first syllables which I shall give you.

3. Read aloud until I say "Stop."

4. Fill in the second syllables on a second list which I shall give you.

This procedure will then be repeated.

As to the recalls: Wait for my write signal before you begin to write the syllables and please say 'Now' when you have finished or are quite sure you can recall no more. Recall as many as you can, but do not delay unduly in trying to get all the syllables. A time record is taken on these recalls."

No preliminary practice was given this group at this time.

All other subjects were asked to read the instructions of Experiment IV and were then shown a list of three pairs and asked for recall as a pre-

liminary trial. The experiment proper followed immediately. It will be noted that this preliminary practice was less than that given to the subjects in Experiment IV.

The Records Taken: The same records were taken as in the preceding experiment: (1) correct recalls, (2) total time, and (3) time for each syllable recalled, whether correct or incorrect. However, the timing apparatus was entirely changed as described below. Scoring was done by the Kjerstad method as before. (A comparison of scores on the same data when scored by this method and the arbitrary method used in Experiment III showed but very slight differences in general results.)

The Timing Apparatus. The total time of recall as well as the time of recall of each syllable was recorded on a kymograph drum by means of two writing levers, one attached to a clock making contacts at one second intervals, the other attached to a key operated by the experimenter. The subject wrote in sight of the experimenter as before. As the

"Write" signal was given, the experimenter struck the key twice in rapid succession; the completion of each syllable by the subject was indicated by one touch on the key, while the subject's "Now" signal was recorded by three contacts. Time was then computed by comparing the two kymograph tracings. Interpolations were made to one half a second.

The Subjects. Forty-eight subjects were used. They may be divided into three groups with respect to their experience with the problem: (1) 10 subjects from Experiment III, together with a member of the faculty, (2) 20 subjects from Experiment IV, and (3) 18 subjects who were entirely without experience.

The Interpolated Activity. During the interpolated interval of the control test the subjects read aloud for two minutes from Wood's "The Influence of Monarchs." At the beginning of the interpolated period of the test situation the electric bracelets were put on the subject and he was handed the book with the instructions to read until told to stop. The cur-

rent was turned on from three to six times according to the reaction of the subject. The rheostat was always set at about half way for the first shock. If the subject reacted rather violently, the current was slightly reduced, otherwise it was usually increased for each successive shock. Five seconds before the end of the period the gun was fired.

Description of Reactions. The subjects' reactions to the emotional stimuli were much the same as those described in Experiment IV. The shock was practically always effective in changing the quality of the reading and always produced a sudden contraction of the arm muscles.

Two of the new subjects were particularly concerned as to the knowledge and responsibility of the experimenter with respect to the strength of current employed. The experimenter did not answer questions, but did ask if their hearts were all right. One subject from the graduate group became rather hysterical and cried at the second shock so that reading was impossible. Another graduate subject

gave a very violent reaction to the revolver report, jumping so that he bumped his knee very heavily against the table. A number of subjects showed their emotional state by excessive perspiration of the hands, which of course enhanced the shock. This excessive moisture was noted by the experimenter when the bracelets were removed.

The Results. Table 8 shows the results of Experiment V in terms of individual and average percentage of recall after interpolation in relation to the recall before interpolation for both control and experimental situations. Again the recall before interpolation was taken as 100% and the recall after interpolation is given on that basis. The average percentage retained under the control situation is 96.02, or in terms of percentage lost, the figure is 3.98%. The P. E. of this difference (using recall before interpolation as 100%) is 1.9%; the chances are then but 79 in 100 that the real difference is more than zero. Under the test situation, however, the loss is 17.80%. The P. E.diff. is 3.7;

Table 14. Percentage of Recall after Interpolation in Terms of Recall before Interpolation.

Subject	Control	Test
1	100.00	100.00
2	83.33	26.32
3	91.80	87.76
4	100.00	83.33
5	97.44	97.00
6	48.93	100.00
7	76.39	0.00
8	89.27	50.00
9	124.00	93.33
10	100.00	100.00
11	100.00	54.74
12	84.44	25.00
13	83.10	84.21
14	78.95	75.00
15	94.55	100.00
16	100.00	76.00
17	86.96	100.00
18	100.00	100.00
19	80.00	100.00
20	125.00	52.63
21	85.71	80.00
22	70.00	92.00
23	17.65	85.11
24	100.00	44.22
25	92.00	59.55
26	93.11	100.00
27	70.00	91.23
28	250.00	92.63
29	86.21	78.63
30	95.00	61.40
31	101.39	82.61
32	100.00	100.00
33	100.00	93.75
34	101.51	180.00
35	114.29	100.00
36	50.70	84.82
37	131.51	66.67
38	100.00	78.67
39	109.10	102.24
40	96.00	91.67
41	100.00	95.06
42	94.74	95.00
43	108.70	44.44
44	25.00	100.00
45	96.00	73.47
46	107.69	76. 71
47	82.86	40.48
48	187.50	82.20
Average	96.03	17.80
"Difference"	3.97	3.7
P. E. diff.	1.9	

the difference is therefore reliable, the chances being approximately 100 in 100 that the real difference is more than zero.

Again the phenomenon of greater recall after interpolation than before appears in 11 cases out of the 48 in the control situation, but in only two cases in the test situation.

The fact was mentioned above that this experimental group might logically be divided into three groups, (1) a relatively experienced group, (2) a slightly practiced group, and (3) a naive group. It may be interesting at this point to examine the recall records for these groups.

Table 15 shows the results obtained from Group I, the nine graduate students, one senior who had served in the preliminary experiments and in Experiment III, and one member of the faculty. Only two subjects of this group retained more during the test situation than during the control situation. The results of one of these, Subject 6, the one showing the greatest difference, are explained by

Table 15. Percentage of Recall after Interpolation in Terms of Recall before Interpolation.
Group I.

Subject	Control	Test
6	48.93	100.00
7	76.39	0.00
11	100.00	54.74
12	84.44	25.00
18	100.00	100.00
20	125.00	100.00
21	85.71	52.63
33	100.00	100.00
44	25.00	44.44
47	82.86	76.71
48	187.50	90.48
Average	92.17	67.64
"Difference"	7.83	32.36
P. E.diff.	5.46	9.51

the fact that, according to his own statement, he used a different method of study in the test situation. He attempted to learn only four syllables of the six and the result was overlearning. In the control situation this subject attempted to learn all six of the syllables and in addition was disturbed because he was convinced that the syllables were presented only four times instead of five.

The average losses for this group are 7.83± 5.46 and 32.36±9.51 for the control and test situations

respectively. The chances that the first difference is reliable are only approximately 83 in 100, while for the latter they are 98.9 in 100. If the record of Subject 6 is eliminated, the differences are 3.59 ±3.98 and 35.60±9.61, respectively; the first is obviously not reliable, while the chances that the latter is reliable are 99 in 100.

Table 16 shows the data for Group II, which was composed of 20 of the 29 subjects who had served in Experiment IV. Average losses are 8.29±4.16 and 13.78±5.18. The chances in 100 that these differences are reliable are approximately 91 and 97 respectively. Three of the members of this group recalled more after interpolation than before in the control situation as compared with one in the test situation.

The same data for Group III, 18 new subjects, are shown in Table 17. The differences between recall before and after interpolation in this group are 4.76±3.51 and 13.22±5.36 for the control and test situations respectively, the former being a gain. Seven of this group recalled more after interpolation

Table 16. Percentage of Recall after Interpolation in Terms of Recall before Interpolation.
Group II.

Subject	Control	Test
1	100.00	100.00
2	83.33	26.32
3	91.80	87.76
4	100.00	83.33
8	89.27	50.00
14	78.95	75.00
15	94.55	100.00
16	100.00	76.00
19	80.00	100.00
23	17.65	92.00
24	100.00	85.11
26	93.11	59.55
27	70.00	100.00
31	101.39	61.40
32	100.00	82.61
35	114.29	180.00
39	109.10	78.67
41	100.00	91.67
42	94.74	95.06
45	96.00	100.00
Average	91.71	86.22
"Difference"	8.29	13.78
P. E.diff.	4.16	5.18

than before under the control test, while this is true of only one subject in the test situation. The chances in 100 that the differences are reliable are 82 and 95 respectively, neither meeting the requirement for

absolute reliability, although the latter is considerably nearer the criterion than the former.

Table 17. Percentage of Recall after Interpolation in Terms of Recall before Interpolation.
Group III.

Subject	Control	Test
5	97.44	97.00
9	124.00	93.33
10	100.00	100.00
13	83.10	84.21
17	86.96	100.00
22	70.00	80.00
25	92.00	44.22
28	250.00	91.23
29	86.21	92.63
30	95.00	78.63
34	101.51	93.75
36	50.70	100.00
37	131.51	84.82
38	100.00	66.67
39	96.00	102.24
43	108.70	95.00
46	107.69	73.47
Average	104.76	86.78
"Difference"	4.76	13.22
P. E.$_{diff.}$	3.51	5.36

The following table summarizes the results in terms of recall for the three groups. The fourth and seventh columns give the number of chances in 100

that the true difference is greater than zero.

Table 18. "Differences" and the Reliability of the Difference for Groups I, II, and III.

	Diff.	P. E.	Chances	Diff.	P. E.	Chandes
Group I	7.83	5.46	83	32.36	9.51	99
Group II	8.29	4.16	91	13.78	5.18	97.
Group III	4.76	3.51	82	13.22	5.36	95

The differences obtained under the test conditions are considerably more reliable than those of the control situation. The greater loss for Group I under the test situation seems rather significant since these subjects had all gone through the disturbing situation a number of times and had become very strongly negatively conditioned to the whole situation. The results at least suggest that this stronger reaction may have produced a greater inhibition. The results of the other two groups, one with a little experience, the other with none, are

approximately the same.

Time records are presented in Table 19. The table is in the same form as that showing time records for Experiment IV. The same phenomenon is

Table 19. Average Time in Seconds for Each Syllable and Average Total Time.

	Control				Test			
	Before		After		Before		After	
Syl.	Ave.	N	Ave.	N	Ave.	N	Ave.	N
1	3.8	44	3.9	46	2.5	46	7.3	46
2	4.4	43	7.6	44	6.7	46	6.0	45
3	7.5	39	4.0	38	4.4	45	4.3	41
4	7.3	34	8.5	30	7.2	44	5.6	37
5	3.9	27	3.1	29	6.0	32	2.4	26
6	4.5	12	8.1	14	6.8	16	6.9	15
Tot.	42.6	46	40.3	46	37.8	46	36.6	46
M. V.	17.4		21.1		13.4		14.8	

shown here as was shown in Experiment IV. Time for recall of the first syllable was greater after the emotional interpolation than at any other time. This holds true for the first syllable only. In the other syllables, as well as in the total time of recall, the records are nearly the same for all recalls, with a

slight tendency toward a decrease in time for the recall after interpolation in the test situation. As before, there seems to be a temporary blocking with a subsequent facilitation after the disturbing situations.

Conclusions. The results of Experiment V have confirmed those of Experiment IV, where there was shown to be a greater loss in retention following a disturbing situation than following normal reading. There is also shown to be a temporary blocking and possibly a later tendency toward facilitation after the disturbing situation.

GENERAL SUMMARY AND CONCLUSION

The influence of bodily disturbances upon retention has been studied in the experiments reported in this paper. Five experiments were carried out, three with the use of the recall method and two with the right associates method.

The three experiments with the recall method failed to indicate conclusively that there was

emotional interference so far as the total recall records were concerned. However, the averages of the recall records of the test situations were in all experiments slightly lower than the averages obtained under the control conditions. These differences were not statistically reliable, but the mere fact of the consistent tendency may be significant. In one of these experiments where the records of total recall time were taken, the figures failed to show the effect of interference. A study of the time per syllable correctly recalled in this experiment did indicate some inhibition.

Two experiments with the right associates method show evidence of emotional interference in both the recall records and the recall time for each syllable. The latter records show that there is a temporary blocking of recall after the disturbing stimuli have been interpolated. This blocking soon passes off and may give way to slight facilitation.

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Appendix

A QUANTITATIVE STUDY OF THE SIMILARITY FACTOR IN RETROACTIVE INHIBITION*

Introduction

Upon the basis of all the experimental work that has been done in the field of retroactive inhibition only two conclusions seem justified: In the first place, an activity interpolated between learning and recall does interfere with that recall. In the second place, the degree of such interference varies with certain relationships between the original and the interpolated activities. Just what the important factors in these relationships are has not been determined, although a number of experimental studies have been made in the effort to discover the basic principles.

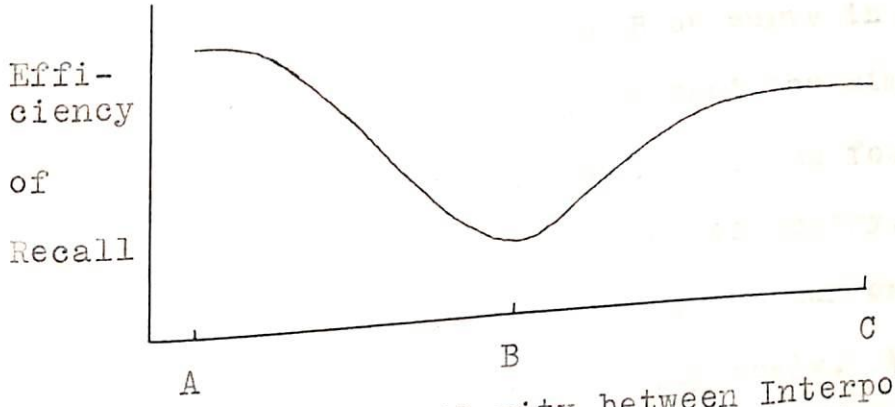
One factor which has seemed important in this regard is the similarity between the original and the interpolated activities. Rather definite laws or principles have been suggested by Robinson (1) and Skaggs (3) and at least partly substantiated by Whitely (4). Recently, however, Robinson (2) has made a new experimental attack on the problem. In this study he fails to verify the theoretical relationship between similarity and retroaction which he and Skaggs had previously postulated.

*This appendix is now in press and will appear in J. Gen. Psychol., 1929, 2, ---.

The theoretical relationship, Robinson (2,p. 298-299) says, seems to be something like this: "As similarity between interpolation and original memorization is reduced from near identity, retention falls away to a minimum and then rises again, but with decreasing similarity it never reaches the level obtaining with maximum similarity." This relationship is graphically represented in Figure I (copied from Robinson), page 3.

Robinson (2, p. 200) has shown experimentally that "where the interpolated activities can be ranked according to their similarity to the original learning, the recall values fell in the inverse rank order. That is to say, the greater the similarity, the less efficient the recall. He quotes the following as an example: "...memorization of a set of 8 four-place numbers was followed by memorization of another set of such numbers or by memorization of poetry. The rank order according to similarity is here perfectly definite and so were the recalls attained after these different types of interpolation." He points out two faults in such an experimental test of the similarity problem: (1) In the first place it shows but one phase of the presumed relationship,

FIGURE I



Degree of Similarity between Interpolated Activity and Original Memorization--Descending Scale

(From Robinson) "Similarity and Efficiency of Recall.

"At A, where similarity between interpolated activity and original memorization is at a maximum (where they are as nearly as possible identical), recall is at its highest level of efficiency. As this similarity approaches its minimum at C it passes through an intermediate degree, B, where recall is exceedingly inefficient. After this point is passed, there is an increase in efficiency of recall, but this increase does not return to the level obtaining at A."

the increase of recall with increased dissimilarity (B to C on the curve in Figure I); it does not show the variation from near identity to non-identity of the same type of material (A to B on curve in Figure I). (2) The second difficulty is that the similarity of the activities employed, i.e., learning four-place numbers, memorization of digits, or of poetry, etc., can never be measured. These processes can only be ranked on a similarity-dissimilarity scale. Hence results obtained from experiments utilizing such materials can be quantitative only in a very rough sort of way.

In order to avoid these difficulties Robinson devised an experimental situation in which he used but one type of material (consonants) and varied the degree of identity between the original and interpolated lists in a manner which may be schematically shown as follows:

Degree of Identity	Arrangement of Items							
	a	b	c	d	e	f	g	h
None in common	$\frac{a}{a}$	b	c	d	$\frac{a}{e}$	f	g	h
One in common	a	$\frac{b}{b}$	c	d	e	$\frac{f}{f}$	$\frac{g}{g}$	h
	a	b	$\frac{c}{c}$	d	e	f	g	$\frac{h}{d}$
Two in common	$\frac{a}{a}$	$\frac{b}{b}$	$\frac{c}{c}$	$\frac{d}{d}$	$\frac{a}{e}$	$\frac{f}{f}$	$\frac{g}{g}$	$\frac{h}{d}$
	a	b	c	d	e	f	g	h
	a	b	c	d	e	f	g	h
	a	b	c	d	e	f	g	h

Three in common	a	b	c	d	a	b	c	h
	a	b	c	d	e	f	c	d
	a	b	c	d	a	b	g	d
	a	b	c	d	a	b	c	d
Four in common	a	b	c	d	a	b	c	d

It should be remembered that the actual experiment utilized only consonants. The first four members of a series of eight consonants represented the original series, the second group of four were considered as the interpolated list. The experimental method employed will not be described at this point, for that described later in the experimental section of this paper duplicated it as nearly as possible.

The results obtained by Robinson with this arrangement of material do not show the theoretical relationship of Figure I. The curves of percentage of recall do not characteristically display the final rise shown in that figure (B to C). He therefore concludes that (2, p. 312) "however many may be the conditions under which there is a first order inversion in the debated function, there are demonstrable conditions under which such inversion is absent."

The failure of Robinson's results to display the final increase in retention seems to the writer only

to be expected for it appears that he has carried the experiment only through the first phase, i.e., from A to B in Figure I, the phase that has been neglected heretofore. In former studies both he and Skaggs have used the term similarity to indicate the same type of material and dissimilarity to indicate a different type of material. For instance, if nonsense syllables were used as original learning material and a second list of nonsense syllables were used as interpolated material, the materials were described as similar. On the other hand, if three-place numbers as interpolated material followed nonsense syllables as original material, the relationship was described as dissimilar. It is clear that according to this concept of similarity and dissimilarity, Robinson dealt only with similar materials in his recent study, since he used consonants as both original and interpolated materials.

The purpose of the present paper is to supplement Robinson's study by introducing varying degrees of dissimilar material (digits) in the interpolated lists, using consonants as original learning material. Robinson's results are accepted as showing the proper

relationships for the various degrees of identity. The present paper will show the effect of varying the digit-consonant make-up of the interpolated list in the same manner as Robinson varied the identical-non-identical consonant make-up of his interpolated lists. Speaking in terms of the curve in Figure I, the purpose of this paper is to determine experimentally the course of the curve from B to C.

The question will undoubtedly be raised as to whether or not consonants and digits are really dissimilar. The answer can only be given in terms of the results of this experiment: Four digits presented immediately after four consonants affect the recall of those consonants less than do four other consonants presented under the same circumstances as were the digits. In this respect, then, we may say that digits and consonants are dissimilar.

THE EXPERIMENT

The Problem: Specifically stated the problem studied was this: How does the interference in the recall of four consonants vary with the consonant-digit composition of a list of four members presented immediately following the presentation of those consonants?

Materials: Two series of thirty lists each were prepared. Each list was composed of eight members, the first four of which were consonants selected at random except that particular pains were taken to avoid certain relationships such as familiar combinations, rhymes, well-known abbreviations, initials, etc. These four consonants corresponded to the original learning material of the typical experimental study of retroactive inhibition. The remaining four members of each list served as the interpolated material and consisted of various arrangements of consonants and digits. The composition of the lists may be schematically shown as follows. It must be remembered that the letters represent random arrangements of consonants, and that the digits were presented in random order, no two occurring in regular ascending or descending order, and such arrangements as 2, 4, 6, or 3, 5, 7, or 3, 6, 9, etc., being carefully avoided.

Degree of Similarity	Arrangement of Items
	a b c d 1 2 3 4
None in common	a b c d e 2 3 4
	a b c d 1 f 3 4
One in common	a b c d 1 2 g 4
	a b c d 1 2 3 h
	a b c d

Two in common	a	b	c	d	e	f	3	4
	a	b	c	d	e	2	g	4
	a	b	c	d	e	2	3	h
	a	b	c	d	l	f	g	4
	a	b	c	d	l	f	3	h
	a	b	c	d	l	2	g	h
Three in common	a	b	c	d	e	f	g	4
	a	b	c	d	e	2	g	h
	a	b	c	d	l	f	g	h
	a	b	c	d	e	f	3	h
Four in common	a	b	c	d	e	f	g	h

It will be seen that there were thus all degrees of similarity as to content. Such an arrangement calls for only sixteen lists. However, the fact that the conditions are unequally represented in this program had to be taken into account in order to make results for all conditions comparable. Since the maximum number of lists required in any one condition to take care of the position factor was six, this was used as a basis and six lists were prepared for each of the five conditions. This accounts for the thirty lists which were mentioned above as comprising each of the two series.

Method: The experimental procedure followed that described by Robinson as closely as possible. The memory span method was used, each list being exposed

but once. Presentation was made visually by means of a Spindler-Hoyer exposure apparatus. The subject was instructed to pronounce aloud each consonant or digit as it appeared. Each member of the list was exposed for .5 second, and there was a .5 second interval between the members. The total exposure time for each list was therefore about eight seconds. An entire experimental sitting in which the thirty lists were used required approximately thirty minutes. It is not likely that the factor of fatigue was important. However, in order to equalize any possible effects of that factor or of practice, the lists were presented in an irregular order with reference to the degrees of similarity. Written recall for each list followed immediately after the exposure of the eighth member of the list.

Each subject served four times and was given the complete series of thirty lists at each sitting. At the beginning of the first sitting a trial series of five lists was given to each subject to acquaint him with the method. Since the memory span method was used and it seemed very unlikely that learning occurred, it seemed permissable to use each series twice, so Series I was given on the first and third experimental

days and Series II on the second and fourth days.

Scoring was based on the correctness in kind and position of each of the first four consonants of each list.

Subjects: Eight graduate students in the Department of Psychology, one Professor of Psychology and one secretary in the Department, a college graduate, served as subjects. All subjects knew the general nature of the experiment, but none knew the details. Most important of all, no one knew that only the first four members of the list were to be scored.

Results: The results in terms of percentage of recall of consonants correct in kind and position are presented in the following table. The figures for the individual subjects represent the average percentage of correct recall of 96 consonants under the condition specified (four consonants in each of the six lists which were presented at each of the four experimental sittings). Since there were ten subjects, N for the general averages under each condition is 960.

Table 1. Percentage of Correct Recall for each Subject under Each Condition and also the Averages for the Group.

Degree of Similarity	4	3	2	1	0
Subject					
1	76	68	77	84	94
2	51	49	31	33	58
3	59	62	57	63	80
4	80	74	82	71	90
5	68	51	69	61	83
6	56	61	59	55	85
7	80	87	77	82	92
8	100	100	95	100	98
9	52	48	51	41	79
10	70	66	77	64	81
Averages	69.2±1.01	66.6±1.02	67.5±1.01	65.4±1.03	84.0±0.08

From these data it appears that recall is considerably better under the 0-in-common condition than under any other. The group averages show differences between this condition and others varying from 14.8% to 18.6% with a P. E.diff. of 1.3% in each case. Of the individual records all except that of Subject 8 show the same tendency. It may be stated here that

the record of this subject shows that the experimental situation was too limited in extent to furnish a test of his memory span, only three errors occurring during the entire series. His record is therefore not significant for our problem.

A casual observation would indicate that the 4-in-common condition, that is, the condition of greatest similarity between original and interpolated lists, does not produce the greatest degree of interference, but that the mixed material is more effective in this respect. However, the reliability data show that the differences between the 1-, 2-, 3-, and 4-in-common conditions are really not significant, the differences varying from 0.9% between the 2- and 3-in-common conditions to 3.8% between the 1- and 4-in-common conditions with a P. E.diff. of 1.6% in each case. The individual records show great variability on this point.

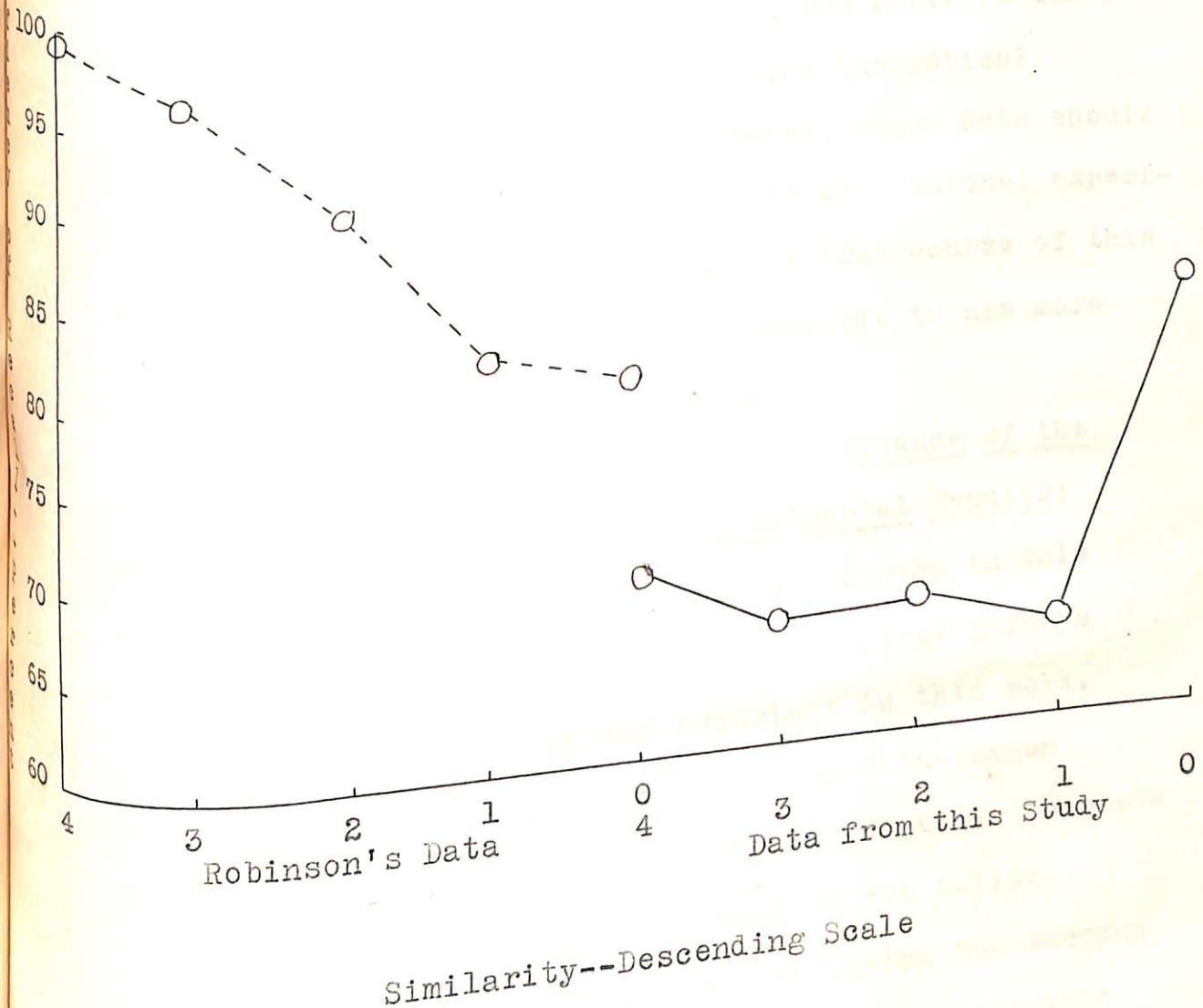
The general tendency as shown by the data obtained is clearly seen from the following graphic representation. In order to show the relationship between Robinson's results and those of the present study a copy of his curve is shown in dotted lines on the

same graph. As explained above, and as indicated on this graph, the 0-in-common condition of Robinson's study corresponds to the 4-in-common condition of this study. (figure II, page 15.)

The discrepancy in the percentage of recall (approximately 80% for Robinson and 69.2% in this study) is probably due to unavoidable differences in the experimental conditions. Robinson's data were obtained from an experimental class of 20 students, who worked in couples, serving alternately as E and O, while the writer acted as E all through the present experiment. The exposure apparatuses were probably different also. The averages for the 0- and the 4-in-common conditions of this study are based upon more data than Robinson had for these conditions. However, for the 1-, 2-, and 3-in-common conditions he had more data than was used in the present averages.

It will be seen that the course of that part of the curve which corresponds to B to C on Figure I follows the theoretical curve in one respect only, it does display a final rise. The shape of this part of the curve, however, is quite different from that of the theoretical curve. It shows a very sharp final rise

FIGURE II


100
95
90
85
80
75
70
65
60
4
3
2
1
0
4
3
2
1
0
Robinson's Data
Data from this Study
Similarity--Descending Scale

from a rather persistent low level, rather than the relatively rapid initial rise from B and gradual leveling off as the curve approaches C, the point of greatest dissimilarity. In other words, the curve obtained from these data is concave, while the theoretical curve is convex from B to C. However, these data should be regarded as suggestive and not final. Further experimentation is necessary to decide the true course of this part of the curve. It would be desirable to use more degrees of similarity in such work.

The Possibility of the Significance of the Factor of Difficulty in these Experimental Results: Voluntary reports of the subjects who served in this experiment have led the writer to think that perhaps the factor of difficulty was important in this work. Without exception they stated that the O-in-common lists were easier to remember than the others. Complete records were not kept of the recall of the entire eight members of the lists. However, using the records from six sittings, i.e., the recall of 288 consonants and digits (8 in each of 6 lists under each condition in each of the 6 periods) the following percentages of

correct recall for the eight members are obtained:

0-in-common	88.9%
1-in-common	67.7%
2-in-common	62.2%
3-in-common	59.4%
4-in-common	59.4%

Do these figures mean that digits are more easily remembered than consonants? If so, the effective factor may have been the relative difficulty of the interpolated material rather than the degree of similarity between original and interpolated materials. This factor has been suggested by Webb (4) as the important one in determining the degree of interference, but it has received no further attention. The factor might also have been operating in Robinson's experiment, since it would undoubtedly be easier to remember the 4-in-common lists, and others in descending order, for the first four consonants were either wholly or in part repeated in the last four members of the lists.

In the present experimental situation the relative importance of difficulty and similarity can be determined by reversing the position of the consonants and digits in the lists. Then if the digits are simply more easily remembered than consonants, we might

expect to obtain results showing the most efficient recall on the 4-in-common (eight digits), the "similar," condition. If, on the other hand, similarity is the important factor, the most efficient recall should occur with the 0-in-common condition, as in the present experiment. Such an experiment has been planned by the writer, but as yet it has not been carried out.

Summary and Conclusions: In this experiment an attempt has been made to study the similarity factor quantitatively by the memory span method. Two types of material, consonants and digits, and five degrees of similarity between original and interpolated lists were used.

The results obtained show that recall is more efficient when the original and interpolated materials are most dissimilar than when these materials are similar or mixed. When combined with the results of Robinson's recent experiment they indicate that the theoretical relationship represented in the curve in Figure I holds in part. Robinson's results show that the relationship shown from A to B on the curve (from identity to non-identity of original and interpolated materials) is probably the true one. The results of the present study

indicate that there is a final rise in the curve as shown from B to C on the theoretical curve, but they suggest that the shape of the curve between these points may be concave rather than convex.

It has been suggested by remarks of subjects and by some experimental data that the relative difficulty of the interpolated material may have been a factor in determining the degree of inhibition shown in the results of this study. Further work has been planned to determine whether or not this is the case.

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Miss Harden

Carl Murchison

THE EFFECT OF EMOTIONAL REACTIONS UPON RETENTION

The purpose of this study is two-fold: (1) It proposes to review and summarize the literature on the problem of retroactive inhibition. (2) It reports in detail a study on one particular phase of retroactive inhibition, which the writer has chosen to term emotional interference.

The first section deals with the work of the following writers: Müller and Pilzecker, Heine, DeCamp, Tolman, Robinson, Skaggs, Harden, Whitely, McGeoch, Hinrich, Lund, Jenkins and Dallenbach, Dahl, Webb, Brockbank, and Hunter and Yarborough. Concluding that section there is presented a summary and present status of the following problems: (1) the existence of retroactive inhibition in recall memory, (2) the existence of retroactive inhibition in recognition memory, (3) factors influencing the degree of retroactive inhibition: (a) temporal position of interpolation, (b) similarity of the original and interpolated activities, (c) degree of learning, (d) practice, (e) conditions of learning, (f) length of series, (g) individual variation, (h) age, (i) sleep, (j) hypnosis, (k) difficulty of the interpolation, (4) the relative susceptibility of rats and human beings to retroactive inhibition, and (5) forward reference <u>vs</u>. retroactive inhibition.

In the experimental part of the thesis five experiments

are reported, all of which deal with this question: What is the effect upon retention of interpolated emotional disturbances?

The general method followed was that employed in all studies of retroactive inhibition. A comparison was made of records made on two tests, one (the control situation) in which original learning was followed by the reading of ordinary prose, and another (the test situation) in which original learning was followed by some general bodily disturbance.

Table 1 summarizes conditions and results of two preliminary experiments. Under "Exp." is given the number of the experiment. "N" represents the number of subjects. "C" and "T" indicate the control and test situations, respectively. Under "Interpolated Interval" is shown the length of time and the type of activity utilized. "Percentage Loss" is given in terms of the difference between recall records taken before and after interpolation.

Table 1.

Exp.		N	Interpolated Interval	Percentage Loss	M. V.
1	C	12	3 min. reading	12.8	4.2
	T		3 min. identifying odors (strong ammonia)	13.7	3.7
2	C	11	3 min. reading	15.9	5.4
	T		3 min. reading with chair-fall, flash, and noise	17.8	5.4

From these results it appears that under the conditions here described a so-called emotional disturbance has no more detrimental effect upon retention that has the reading of ordinary prose.

In Experiment 3 recall and time records were taken after five different interpolated activities: (1) reading ordinary prose (the control activity); (2) reading aloud from a humorous selection; (3) reading with revolver report; (4) reading with electric shock; and (5) reading with shock or threatened shock, loss of bodily support, and revolver report. Ten subjects served and each had five experimental sessions. Nonsense syllables, three-place numbers, and three-letter words were used as original learning materials. The following conclusions are suggested by the results obtained:

1. The recall records, when averaged, give negative results so far as evidence of emotional interference is concerned. However, since individual records show that in 66% of all the test situations recall is less than that in the corresponding control tests, inhibitive effects are indicated. Individual cases where reactions were unusually marked show comparatively great loss in the recall records.

2. Total time records for recall of the nonsense sylla-

bles and words ratherconsistently indicate interference in the test situations. Sixty-seven per cent of the individual records indicate greater recall time in the test situations.

3. The average time taken per syllable correctly recalled very consistently indicates some interference of the test situations, as does also the average time per number and word correctly reproduced. Seventy per cent of the individual records show the influence of such interference.

Experiments 4 and 5 deal with the effect of electric shock, loss of bodily support, and the revolver report upon retention. The right associates methods was employed in both of these experiments. Twenty-nine subjects served in Experiment 4 and 48 served in Experiment 5. Recall records (before and after interpolation), total time and time for each syllable were recorded. The results indicate that the emotional reactions affected the retention of the subjects. Evidence for such emotional interference was found in both the recall and the time records. A particularly interesting fact which was brought out in the time records was the temporary blocking and later facilitation of the recall after the disturbing interpolation.

A bibliography of 30 titles concludes the paper.

Luberta Marie Harden

A QUANTITATIVE STUDY OF THE SIMILARITY FACTOR IN RETROACTIVE INHIBITION

A minor study of the similarity factor is reported as an appendix. In this study the writer has supplemented the experiment reported by Robinson in which he determined the effect upon retention of varying the degree of identity of original and interpolated materials. The writer varied the degree of similarity, i.e., the digit-consonant make-up of a list which was interpolated between the learning and recall of consonants.

The memory span method was employed, and 30 lists of eight items (four for original and four for interpolated material) were presented on a Spindler-Hoyer apparatus. Each of ten subjects served four times, and studied 30 lists at each sitting.

Robinson's results had indicated that the effect of identity or original and interpolated materials varied directly with the degree of identity. The results of this study show that the effect of the degree of similarity is practically equal when there are four-, three-, two-, and one-items-in-common, but that retention is much better when the materials are dissimilar, i.e., no-items-in-common.

Luberta Marie Harden